1913

Transcript of Record, Volume III: The Wright Company vs. The Herring-Curtiss Company and Glenn H. Curtiss

United States Circuit Court of Appeals, Second Circuit

United States Circuit Court of Appeals

FOR THE SECOND CIRCUIT

THE WRIGHT COMPANY

Complainant-Appellee

vs.

THE HERRING-CURTISS COMPANY AND GLENN H. CURTISS

Defendants-Appellants

TRANSCRIPT OF RECORD

APPEAL FROM THE DISTRICT COURT OF THE UNITED STATES FOR THE WESTERN DISTRICT OF NEW YORK

Vol. III

PRINTED UNDER THE DIRECTION OF THE CLERK

Toulmin

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1843

New York, N. Y., April 16, 1912.

Testimony taken in behalf of defendants, pursuant to order of the Court, dated April 11th, 1912, and oral notice and agreement between counsel on the same date, commencing at 10.30 A. M. April 16th, 1912, before Beatrice Mirvis, Notary Public, at the office of Emerson R. Newell, No. 2 Rector Street, New York City, N. Y.

Present—H. A. Toulmin, Esq., for Complainant.
Emerson R. Newell, Esq., for Defendants. 1844

Mrs. META MATTULLATH, a witness introduced on behalf of defendants, having been duly sworn, deposes and says in answer to questions by Mr. Newell:

By Mr. Toulmin: At the outset, and once for all to save repetition, I object to any testimony by any witness and to any document concerning the alleged Mattullath invention as the same is held to be incompetent for any purpose whatever in this case.

Q1. Please state your name, age and residence? 1845
A. Meta Mattullath, age 63, residence 100 West 71st Street, New York City.

Q2. Your counsel, Timothy D. Merwin, Esq., is here in the room representing you, is he not?
A. Yes.

Q3. You are the widow of Hugo Mattullath?
A. Yes.

Q4. And also the Administratrix of his estate?
A. Yes.

Q5. You are the Mrs. Meta Mattullath mentioned in the proceeding in the Court of Appeals for the

1846 District of Columbia, January Term, 1912, patent appeal docket #751, and entitled, "In the Matter of the Application of Meta Mattullath, Administratrix of Hugo Mattullath?"

A. Yes.

Q6. This proceeding was an appeal to said Court of Appeals praying for the revival of your husband's application for a patent on Flying Machines, said application being Serial Number 751, filed January 8, 1900?

By Mr. Merwin: Objected to as irrelevant and immaterial, since the public records of the Court in question are the best evi-
1847 dence, and further because it is an inquiry into a pending application as to which she stands in a position of the applicant being his Administratrix, and as under the rule of law and the statute the witness in such position cannot be compelled to disclose a secret process invention or discovery (Section 4908, R. S.), and the witness is instructed that she need not answer unless the Court shall order her so to do.

By Mr. Newell: The objection is not of much force, particularly as a certified copy of the Mattullath application is already in
1848 evidence as Defendant's Exhibit "Mattullath Application," said exhibit (a certified copy) being now exhibited to the witness and Mr. Merwin.

By Mr. Merwin: It is further to be noted that the certified copy referred to was obtained from the Patent Office improperly and without warrant of law, on the ground that the application in question was abandoned; that at the present time, by virtue of the judgment of the appeal to the District of Columbia, the same is now alive and a

pending application whereby the rule of law 1849
above referred to applies to the same, and
the witness is not compelled to answer questions respecting the same or tending to disclose anything regarding the invention involved, and the witness is instructed again that she need not answer the questions propounded without an order of the Court so to do.

By Mr. Newell: The certified copy was obtained in the Fall of 1909, by obtaining an order of the Circuit Court for the Southern District of New York, and by motion to the Commissioner of Patents based 1850
thereon and which motion was granted.

By Mr. Merwin: The expression in my prior objection as to the procurement of the certified copy being "improper and without warrant of law" was and is not intended as any reflection upon counsel or the Court, but that as a matter of fact as now developed by virtue of the judgment of the Court of Appeals of the District of Columbia, counsel for the defendants herein was not entitled to said certified copy and the Court granted the order on the misapprehension of the true facts of the case. Counsel further states 1851
that as to this particular question there is no objection to it appearing that Mrs. Mattullath was the petitioner in said proceeding since the same appears as of record in said Court.

A. Yes.

Q7. Did you come down here voluntarily to testify, or were you subpœnaed?

A. I was subpœnaed.

Q8. The subpœna *duces tecum* served upon you on April 13, 1912, directed you to bring with you

1852 certain papers or such of them as may be in your possession or control. I show you the original subpœna, of which I observe Mr. Merwin, your counsel, has the copy. Did you bring with you this morning, any of the papers mentioned therein?

By Mr. Merwin: Attention of the Court is called to the rule of law that the authority to issue subpœnas under Section 4906 of the U. S. Revised Statutes does not include authority to issue a subpœna *duces tecum* as laid down in the case of *ex parte* Moses, 53 Federal Reporter, page 348, and
1853 that for that reason the witness cannot be compelled to produce such papers.

Counsel further states that in order to shorten this inquiry that the witness, as a matter of fact, does not have and never has had in her possession or under her control, documents which appear to be called for in this subpœna, and that certainly at the time of the service of the subpœna in question none of such papers were in her possession or under her control. It was and is impossible for her to produce the same were she legally required so to
1854 do.

By Mr. Newell: Section 4906, Revised Statutes only refers to a "contested case pending in the Patent Office," and has nothing to do with a suit such as the present one.

A. No.

Q10. Who is your attorney in your husband's above-mentioned application?

By Mr. Merwin: Objected to because this is another attempt to compel disclosure by the witness of matters in a pending application, which application is in no way concerned in this cause to which the witness is a stranger, and that under the authority of the Revised Statutes above referred to, No. 4908, as well as under the general rules of evidence under which a party cannot be compelled to disclose his own private affairs or secrets in circumstances such as the present and the witness is instructed that she need not answer the question. 1855

A. By advice of counsel, I refuse to answer.

Q11. Is it not Mr. W. H. Swenarton? 1856

Same objection by counsel and same instructions to the witness.

A. I refuse to answer, on advice of counsel.

By Mr. Newell: I do not intend to pry into anything that I am not entitled to, but I do intend to get what I am entitled to in this cause if it takes all Summer. I shall be compelled, if this refusal continues, to apply to the Court for an order directing the witness to answer, and to comply with the subpœna, and all parties are notified that this will be done, in order that this notice may not have to be repeated hereafter. 1857

Q12. When the petition for revival was signed, you were the petitioner and you signed the petition, did you not?

By Mr. Merwin: Objected to as irrelevant and immaterial, because the records of the Court disclose the proceedings called for.

A. Yes.

1858 Q13. Mr. Joseph F. O'Brien was your attorney, and Mr. W. H. Swenarton was your solicitor and counsel, were they not?

> Same objection, and this is understood to be repeated following each question in this line of inquiry.

A. Yes.

Q14. If you had wished, you could have obtained the papers up to the present time in Mr. Mattullath's application from your attorney, could you not?

1859 Same objection as to Q9, and same advice to witness.

A. On advice of counsel, I decline to answer.

Q15. Do you decline to produce the papers mentioned in the last question?

> By Mr. Merwin: The attention of counsel is again called to the statement made upon the record, that the papers referred to are not in her possession or under her control.

A. The papers are not in my possession.

Q16. They are in the possession of your attor-
1860 ney, are they not? A. I don't know where they are.

Q17. You decline to tell me who your attorney is?

> By Mr. Merwin: The objection heretofore entered is renewed, and the witness is instructed that she need not answer, unless ordered so to do by the Court.

A. I decline.

> By Mr. Toulmin: I have no desire to take any part in what is now appearing on

the record, except to call the Court's atten- 1861
tion to the first item called for in the sub-
pœna *duces tecum*. That item calls for the
production of "All Papers up to the Present
Time in the Application of Hugo Mattul-
lath, No. 751, filed January 8, 1900, in the
United States Patent Office." Counsel for
defendants, Mr. Newell, has in his posses-
sion, and has been holding in his hand, a
copy of the transcript of record in the
Court of Appeals, in the Matter of Mrs.
Meta Mattullath, for the revival of the
Mattullath application. This transcript
contains a copy of all the papers connected 1862
with the Mattullath application up to the
time the appeal was perfected and decided.
What the first item in the subpœna calls
for is therefore already in the possession
of counsel for defendants.

By Mr. Merwin: In order to save time and any further unnecessary trouble to the witness, but without waiving any legal objection, counsel states that the attorneys of record for the witness in respect to said application are Joseph F. O'Brien, Esq., and W. H. Swenarton, associate.

Q18. Then if I understand you correctly, you 1863
have none of the papers mentioned in the first
paragraph of the subpœna *duces tecum*, but that
they are in the possession of said gentlemen, your
attorneys. Is that correct?

By Mr. Merwin: The answer of the witness and the statements of her counsel meet all the requirements of the inquiry as to the various papers generally referred to in the subpœna, to the effect that said papers are not and have not been in her

1864 possession or under her control, but as to where such papers may be even if the witness knows, her counsel states that without an order of Court directing her to answer that inquiry she need not answer the same, and may decline to answer under advice of her counsel.

A. I decline to answer, by advice of counsel.

Q19. Have you at any time made any assignment of your rights in the application of your husband?

By Mr. Merwin: As this is another in-
1865 quiry into the private affairs of the witness, and as it is believed to be within the scope of the statute effecting inquiries of such questions, the witness is advised that she need not answer the question unless ordered by the Court.

A. I decline to answer.

Q20. I show you here what purports to be a transcript of record in the Court of Appeals of the District of Columbia in your application for revival of the Hugo Mattullath application. This copy does not belong to me but is the property of your counsel, Mr. Merwin. Can you state
1866 whether or not this copy contains a complete record of the application papers up to the time when the case was decided by the Court of Appeals?

Objected to by counsel for the witness.

A. I never saw it.

Q21. The second section of the subpœna requires you to bring in "Any Letters from Orville or Wilbur Wright relating to said application or to the work of Hugo Mattullath." Did you ever have in your possession any such letter?

Counsel for the witness objects to the 1867
question for the same reasons as above stated in the previous questions, and because the documents were not identified so that the witness would be able to answer the question intelligently, and counsel for defendants is requested to make the question sufficiently specific for that purpose. Further counsel states, it already appears upon the record in this hearing that none of the documents referred to have been or are now in the possession or control of the witness.

A. They are not in my possession and I have 1868
never had a letter from the Wrights.

Q22. In that transcript of record there is printed on page 41 a letter to Miss Alice Mattullath from Wilbur Wright. Do you know who has that letter now, and if so, please state who it is, as I wish to trace it.

A. I do not know.

Q23. In the application of Mr. Mattullath certain letters were filed in regard to your husband's work, and which letters, I am informed, have been withdrawn. Do you know where they are, or who has them?

A. I do not. 1869

Q24. Who do you think has them?

Objected to as entirely improper and as calling for the opinion of the witness and not calling for matters in her own knowledge.

A. I haven't the least idea.

Q25. The fourth section of the subpœna asks you to bring in letters and other documents found among the effects of said Hugo Mattullath after his decease and relating to flying ma-

1870 chines. You have not brought any of these in, I understand. There were a number of letters and other documents of this nature found among the effects of Mr. Mattullath, were there not?

A. I know nothing about them, and never have known.

Q26. Who are the persons who are for you causing the prosecution of the Mattullath application. Please give their names as I wish to ascertain what has been done in the matter, what devices were built, and to trace, if possible, the letters and documents referred to?

A. Mr. Herman L. Behrens, my son-in-law.

1871 Q27. And who is furnishing the money for the prosecution?

By Mr. Merwin: Objected to as improper inquiry as to the witness's private affairs, which has nothing to do with the issues in this cause, and she is instructed that she need not answer.

A. I decline to answer, by advice of counsel.

Q28. I understand that one or more models of Mr. Mattullath's flying machine were made. I desire to find out, first, who made them, and, second, whether they were flown and their con-
1872 struction. If you know who made or had charge of the making of any such model or models, please give his name.

By Mr. Merwin: The question is objected to because it does not specify the date when it is claimed such models were made, and otherwise, because it is subject to the same objection as the preceding questions.

A. I don't know.

Q29. Who would be likely to know about this?

A. I couldn't say.

Q30. Have you, as Administratrix of the estate

of Hugo Mattullath, any objection to my obtaining 1873
a copy of the papers of Mr. Mattullath's application up to and including the decision by the Court of Appeals of the District of Columbia, in order that the same may be introduced in this cause?

Counsel for the witness notes that this is an improper question addressed to the witness, since the management of the application of her deceased husband is entirely in the hands of her attorneys, and because the matter is entirely in their hands, it is improper to ask her opinion or wish as to 1874
proceedings which she has left entirely in the hands of her attorneys.

A. I object, certainly.

By Mr. Newell: As the witness has declined to answer a good many questions, and has failed to bring in any of the papers referred to in the supœna *duces tecum,* although some of them are in the possession of her attorneys, it seems impossible to gain anything by further examination of the witness until the Court has passed upon the matter. Notice is therefore hereby 1875
given to all parties, that, on Friday, April 19th, 1912, I shall apply to the United States District Court for the Southern District of New York, for an order compelling the witness to answer, and to produce the papers referred to. This motion will be placed upon the calendar at once.

Counsel for defendants is not through with the witness, and is willing that she be excused until the Court shall have determined the matter, unless counsel for complainant desires to now cross examine.

By Mr. Toulmin: As the whole matter is

1876 one without any warrant in this case, I see no occasion now to cross examine this lady. So far as I am concerned, she is now discharged.

By Mr. Newell. The witness is excused until Monday, April 22nd, at 10:30 A. M., as this is the first day after Friday, when the motion is to be heard, that Mr. Merwin can conveniently be present.

By Mr. Merwin: As it is assumed that under the notice given by counsel for defendants herein, the record of the proceeding thus far is to be certified to the U.
1877 S. District Court as a part of the motion papers on the application of counsel for an order to compel the witness to answer the questions which she has, under advice of counsel declined to answer. For the information of the Court, counsel would state that both of the parties to this action either are, or undoubtedly will be, hostile and opposed to this witness and the interests which she represents in respect to the application of her deceased husband, which interests her counsel seeks to protect; that he does not wish to withhold any evidence
1878 in possession of the witness which it is proper for either party to the litigation to have, but that he wishes to protect inviolate from any invasion of the rights of the witness and her said interests by either party to this litigation, and he appeals to the Court to enter such order as will ensure such protection, and submits to the Court that if it will mark out the line of invesigation which it is competent and proper for the counsel the parties in said litigation to follow in interrogating this witness or

her attorneys or advisers, the same will be strictly followed by her counsel. 1879

Counsel for defendants herewith introduces in evidence a certified copy of the opinion of the Court of Appeals of the District of Columbia in the Mattullath matter, and requests that it be marked as Defendants' Exhibit "Court of Appeals Mattullath Opinion."

By Mr. Toulmin: As neither complainant nor its assignors were parties to the proceedings mentioned in the opinion, the exhibit is objected to as incompetent. This objection is made once for all. 1880

Adjourned to 2:15 P. M.

Resumed after Recess.

HERMAN L. BEHRENS, having been duly sworn, testifies as follows in answer to questions by Mr. Newell:

Q1. Please state your name, age, residence and occupation?

A. Herman L. Behrens; age 53; residence, 100 W. 71st Street, New York City, N. Y.; occupation apothecary. 1881

Q2. Did you come down here voluntarily or were you subpœnaed?

A. I was subpœnaed.

Q3. You are the son-in-law of Mrs. Meta Mattullath?

A. Yes, sir.

Q4. Will you please state what you have known of what was done during the proceedings taken for the revival of the Mattullath application for flying machine, since such proceedings were started, including a description of any models built, who built

1882 them, and whatever you may know about the matter?

By Mr. Merwin: Objected to, first, because it is an improper inquiry into the private business affairs of Mrs. Mattullath for whom the witness is business advisor, and second, because the subject-matters of the question are not specifically stated so that it would be impossible to determine which, if any, of them can be testified to by the witness. If counsel for defendants will direct his inquiries to specific items, it will more readily
1883 appear as to what of them is proper for the witness to testify to. Until the question is made specific he is instructed that he need not answer.

A. I decline to answer, on instructions from counsel.

Q5. You were present here in the office, although not in the room, while Mrs. Mattullath was giving her testimony this morning?

A. Yes, sir.

Q6. Do you know anything about the building of one or more models of a flying machine like that of the Mattullath application, a copy of which I now
1884 hand you?

By Mr. Toulmin: Objection is made once for all to any alleged models, because the same are incompetent for any purpose in this case, as alleged anticipations or otherwise. This objection is made once for all.

Counsel for Mrs. Mattullath makes the same objection as before to this inquiry of the private business affairs of Mrs. Mattullath as Administratrix of the deceased applicant, and instructs the witness that he

need not answer the question without an 1885
order of the Court compelling him to do it.

A. I refuse to answer, by advice of counsel.

Q7. If you know who built, or had anything to do with the building or tests of any such model, state who it was?

Same objection and same instructions to the witness.

A. I refuse to answer, by advice of counsel.

Q8. Do you decline to answer any questions regarding such models or tests of same?

Same objection and same instructions to 1886
the witness.

A. I refuse to answer, by advice of counsel.

Q9. Do you know anything about the finding, among the effects of Mr. Mattullath after his decease, of any papers of his relating to the work which he did in flying machines?

Same objection and same instructions to the witness.

A. I decline to answer, by advice of counsel.

Q10. If you do know of any such papers, please
state whether they are in your possession or con- 1887
trol, and if they are not, please state to whom they
were given, for I wish to trace them?

Same objection and instructions to the witness.

A. I decline to answer, by advice of counsel.

Q11. Do you own any part of, or are you financially interested in, the application of Mr. Mattullath No. 751; filed January 8, 1900, the copy of which you now have in your hand?

Objected to by counsel for Mrs. Mattul-

1888 lath and the witness on the ground that it is an improper inquiry in the private affairs of the witness, and he is instructed that he need not answer the question unless ordered by the Court so to do.

A. I decline to answer, by advice of counsel.

Q12. The transcript of record of the Court of Appeals for the District of Columbia in the revival proceedings of said application, makes reference, on page 21 thereof, to certain "letters I have handed to you" (that is to the Commissioner of Patents). I show you where that is referred to. I have been
1889 informed that these letters were withdrawn from the files of the application. Did you ever see them and, if so, please state who has them now, to the best of your information and belief.

Same objection by counsel for Mrs. Mattullath and the witness as to Q6, and also because it calls for a disclosure of the contents of the file wrapper of a pending application for a patent. The witness is instructed that he need not answer the question, unless so ordered by the Court.

A. I decline to answer, by advice of counsel.

1890 Q13. Please state whether or not Mr. Mattullath, during his lifetime, constructed or started to construct any flying machine, and if so, state what it was and what you know about it?

Same objection and same instructions to the witness.

A. I decline to answer, by advice of counsel.

Q14. Do you remember meeting me in the outer office of Mr. Swenarton on or about April 5th, 1912?

A. Yes.

Q15. There were two men with you besides Mr. Swenarton. What are their names?

A. I don't remember. 1891

Q16. One was a tall man with a gray beard. You went out with him and the other man. Do you remember now?

A. It must have been Mr. Simon, I think, Mr. Kaufman Simon.

Q17. Where does he live?

A. Broadway and 113th Street, I don't recall the number.

Q18. The other man was Mr. O'Brien?

A. I think so, yes.

Q19. Is Mr. Simon interested in any way in the Mattullath application, so far as you know?

> Objected to by counsel for Mrs. Mattullath on the same grounds as heretofore stated in previous questions, and the witness is instructed that he need not answer the same except by order of the Court. 1892

A. I decline to answer, by advice of counsel.

Q20. I have reason to believe that Mr. Simon knows something about the matters I have been inquiring about. If Mr. Simon is interested in any way in the Mattullath application, please state what interest he has. Also state what, if any, interest he took in the revival of the said application and in the construction or building of any models 1893
of the flying machine?

> Same objection and instructions to the witness.

A. I decline to answer, by advice of counsel.

Q21. Please state what Mr. Simon's business is?

A. He owns real estate in Brooklyn, and develops real estate.

Q22. Do you know where his office is?

A. He has none, that I know of.

Q23. The Mr. O'Brien mentioned in your answer to Q18 is Mr. Joseph F. O'Brien?

1894 A. Yes, sir.

Q24. He is one of the attorneys for Mrs. Mattullath in the application?

A. Yes, sir.

By Mr. Newell: Counsel for defendants asks Mr. Merwin, representing Mrs. Mattullath, if he will furnish a copy of the transcript of record in the Court of Appeals for the District of Columbia, two copies of which are in the room at the present time, that is, printed copies, so that one of them may be introduced in evidence.

1895 By Mr. Merwin: I am not at present able to state whether I can spare you a copy. I do not wish to be deprived of the necessary copies for our own office.

By Mr. Newell: Then at present you decline?

By Mr. Merwin: For the reason stated, yes, at least for the present.

Q25. Do you decline to answer any further questions along this line?

A. I do. Sure I decline the same way.

By Mr. Newell: Notice is hereby given that the motion heretofore noted for Friday,

1896 April 19th, will also include an application to the Court for an order compelling the witness to answer the questions which he has declined to answer.

Unless counsel for complainant wishes to ask the witness something, the witness is excused until April 22nd, 1912, at 10:30 A. M., at the same place, viz., this office.

By Mr. Toulmin: Without waiving the objections, the witness is cross examined.

Cross examination by Mr. Toulmin: 1897

XQ26. In Q14 Mr. Newell asked you if you remembered meeting him in the outer office of Mr. Swenarton on or about April 5, 1912, and you said "yes." Did Mr. Newell make an offer of $1,500 if the parties having control or charge of the Mattullath interests would join him and produce the evidence concerning the Mattullath invention?

A. No, sir.

XQ27. Have you not understood that Mr. Newell made that offer to one of the counsel representing Mrs. Mattullath?

A. No, I did not. 1898

XQ28. Have you any information on that subject?

A. No, sir.

By Mr. Toulmin: Until the witness is reproduced or called again, no further cross examination is desired.

Redirect examination by Mr. Newell:

RDQ29. When I met you in Mr. Swenarton's office, you gentlemen were just going out. Will you please state what I said to you?

A. Mr. Newell congratulated me and Mrs. Mat- 1899
tullath and the family on the decision of the Court regarding the application of the patent, and I think that was all the conversation there was.

RDQ30. So far as you know, did I know anything about the revival proceedings until the decision of the Court of Appeals?

A. Not that I know of.

1900 New York, N. Y., April 16, 1912.

JOSEPH F. O'BRIEN, a witness introduced in behalf of defendants, having been duly sworn, deposes and says in answer to questions by Mr. Newell:

Q1. Please state your name, age, residence and occupation?

A. Joseph F. O'Brien; 34; West New York, New Jersey; patent attorney.

Q2. Did you come here voluntarily, or were you subpœnaed?

A. I was subpœnaed.

1901 Q3. The subpœna *duces tecum* served on you required you to bring in certain papers mentioned therein. Did you bring any of them with you?

By Mr. Merwin: Same objection is interposed to this question and all others which may be asked in this line of investigation as have been heretofore entered with respect to like questions asked of the two preceding witnesses, and he is requested to observe the same instructions as were given by me to those witnesses. A further objection is entered to any questions which may
1902 call for any confidential communications between the witness and his client, and he is requested to properly observe the rule of law in regard to the same.

A. I did not.

Q4. Why not?

Same objection and same request to witness, by Mr. Merwin, and he is requested further not to answer this or any similar question without an order of court compelling him so to do.

A. I decline to answer, by instructions of counsel, and for the reasons stated by Mr. Merwin. 1903

Q5. Are you a lawyer.

A. I am not an attorney-at-law.

Q6. You are the Joseph F. O'Brien named in the transcript of record of the Court of Appeals of the District of Columbia, January Term, 1912, Patent Appeal Docket #751, entitled "In the Matter of the Application of Meta Mattullath, Administratrix of Hugo Mattullath?"

A. Yes.

Q7. Have you, or did you have at the time the subpœna was served on you, in your possession or control any papers in the application of Hugo 1904
Mattullath #751, filed January 8, 1900, in the United States Patent Office?

Same objection and same request to the witness.

A. I decline to answer, by advice of counsel, and for the reasons given.

Q8. Did you at the time the subpœna was served on you, have in your possession any of the papers or documents referred to in said subpœna *duces tecum?*

Same objection and same request to the 1905
witness.

A. I decline to answer, by advice of counsel, and for the reasons given.

Q9. Do you decline to produce any of said letters or documents as were in your possession or control at the time the subpœna was served on you?

A. The question implies that there were documents in my possession or control, and I decline to say whether there were or were not, in accordance with request of counsel.

Q10. Well, I want to know whether any such

1906 papers or documents were in your possession or control, and I consider that I am entitled to know. Please state whether there were or not.

By Mr. Merwin: As counsel for Mrs. Mattullath I desire to state that it is not sought to have any witness subpœnad herein do or fail to do anything which may be in contempt of court, but as it is believed that the documents ordered to be produced by the subpœna are the private papers of Mrs. Mattullath as Administratrix of her deceased husband and are part of the file wrapper and contents of said pending ap-
1907 plication, the Court is requested to advise and direct counsel for Mrs. Mattullath, and this and other witnesses concerned in her private affairs and in the prosecution of said application, as to whether the documents in question or any one must be produced for the benefit of either of the parties to this cause to the inevitable serious prejudice and injury to Mrs. Mattullath and to the invention involved in said application.

A. There were not in my possession or control, and that is the reason they are not produced by me
1908 at this hearing.

Q11. Very well. That being settled, please state which of such papers as are mentioned therein (and I hand you here the subpœna) were at any time in your possession or control, when you parted with them, and to whom they were given? I wish to trace them.

By Mr. Merwin: This being another inquiry into the private affairs of Mrs. Mattullath and in respect to the papers belonging to the file wrapper and contents of said application for patent, objection is made to the question and on the same ground as hereto-

fore stated the witness is requested not to 1909
answer the same without an order of the Court compelling him to so do.

A. I decline to answer on the advice of counsel, for the reasons given.

Q12. Did you not, at the time the subpœna was served on you, or since then, have in your possession or control a copy of the transcript of record mentioned in Q6?

A. I have a printed copy of the transcript of record, but did not suppose it was called for by the subpœna *duces tecum.*

By Mr. Merwin: The attention of the 1910
Court is called to the evident purpose of counsel for defendants to induce the Court to believe that this witness has disobeyed the order of the subpœna when he well knows that the document referred to is not stated in the subpœna.

By Mr. Newell: Counsel's statement that I know that the document referred to is not stated in the subpœna, is false. I know no such thing. On the contrary I believe that such are included within the scope of the subpœna.

By Mr. Merwin: Counsel for defendants 1911
is requested to read into the record the words in the subpœna which call for the production of printed copy of the transcript of record in the Court of Appeals for the District of Columbia referred to.

By Mr. Newell: The first clause of the subpœna reads as follows:

"All papers up to the present time in the application of Hugo Mattullath #751, filed January 8, 1900, in the U. S. Patent Office," 1912 followed by a specification of letters and other documents, and closes with the words "or such of said letters and documents as may be in your possession or control."

Q13. This transcript of record, in which I see you are named as attorney for the petitioner, contains the papers (that is, copies of them) in the application up to the time when the Court of Appeals of the District of Columbia decided the matter?

A. This transcript of record was prepared in the Patent Office under instructions from Mr. Swenarton, and I am not in a position to state whether it contains the copies of all the papers in the appli-
1913 cation referred to. I may state that I have absolutely no objection to producing this transcript of record if permitted to procure the same from my home in West New York. As I read the subpœna it calls for "All papers up to the present time," and it never entered my mind that counsel would construe this meaning a printed transcript of a public record which he might obtain himself in Washington.

By Mr. Newell: For your own guidance I tell you that I telegraphed to-day for a copy, but have just received a telegram say-
1914 ing that copies are exhausted. Will you to-morrow bring in your copy?

A. I will.

By Mr. Newell: Please understand that I ask you to bring in copies of any papers such as named in the subpœna which may be in your posession or control.

Adjourned at 4.30 P. M. to be resumed to-morrow, April 17th, at 11 A. M.

New York, N. Y., April 17, 1912. 1915

Met pursuant to adjournment, at 11 A. M.

Present—Counsel as before.

Witness continues:

Q14. Have you this morning brought in the copy of the transcript which I asked you for yesterday?

A. I have produced the printed transcript of record, which you asked for yesterday. I must refuse, however, to deliver the same on the ground that it is my personal property, the only copy I have, and that it contains certain marks or 1916
annotations which I may need in the further prosecution of the case before the Patent Office. I also produce an uncompared typewritten copy of the decision which was handed to me by Mr. Swenarton's stenographer, with the statement that it was uncompared, and which I now produce and deliver, if it is wanted.

By Mr. Newell: Counsel for defendants herewith introduces the copy of the transcript referred to, and requests that it be marked as Defendants' Exhibit "Mattullath Transcript of Record."

By Mr. Toulmin: Under the circum- 1917
stances which appear of record it would not seem that the transcript has really become a part of this record or has been legitimately identified and offered. But be that as it may, I object to it on the ground that nothing in it can bind complainant or its assignors, since they were not parties to that case in anywise. This objection is made once for all, but that this copy which Mr. O'Brien has been kind enough to show Mr. Newell is uncertified, is of no conse-

1918 quence since objection on that ground would be technical, and I waive any such technicality.

By Mr. Merwin: As counsel for Mrs. Mattullath and the witness, I protest that the attempt to offer this document in evidence, and call the attention of the Court to the fact that the witness refused to deliver the same and only produced it at the hearing because of the contention of counsel for defendants that it was covered by the order in the subpœna. The document is not in the possession of counsel for de-
1919 fendants, and it is respectfully submitted to the Court that the witness should not be compelled to surrender the same to counsel for defendants to be placed in evidence, or for ay other purpose, for the reasons stated by the witness himself.

Q15. Do you decline to deliver the above transcript, which you have in your hand, to the notary for marking as an exhibit in the cause, for I now ask you to hand it to the notary in order that it may be properly marked?

A. As stated above, I decline to deliver the
1920 transcript of record referred to, and will so decline until ordered so to do by the Court. My only reason for producing it at this hearing was to show all due respect to the Court and its process, and any possible construction that might be placed upon the language thereof.

Q16. Have you brought in this morning any other papers?

A. I have brought in no other papers, because no other papers in this case are in my possession or under my control, and have not been in my possession or under my control since the subpœna was served upon me.

Q17. You state in Q14 that the transcript contains certain annotations "which I may need in the further prosecution of the case before the Patent Office." Is this "case" you refer to the Mattullath application No. 751, filed January 8, 1900? 1921

A. Yes, but I would qualify my previous statement quoted in the above question by making it read in "assisting in the prosecution."

Q17a. You are the attorney of record in said application?

A. I am.

Q18. Is any other person now attorney of record also in said application?

A. Mr. W. H. Swenarton is my associate attorney of record. 1922

Q19. Is any one else now attorney of record in said application, and if so, who?

> By Mr. Merwin: Objected to as wholly unwarranted as being an improper inquiry into the proceedings of a pending application in the Patent Office and with an attempt to disclose further business affairs of the witness' client.

A. There is no one else of record in the Patent Office.

Q20. Did you have in your possession at the time the subpœna was served on you, any copy of the papers in the application up to the present time as filed in the Patent Office, and of the letters from the Patent Office, in said application? 1923

A. I did not.

Q21. Mr. W. H. Swenarton, the associate attorney of record, had such copies?

A. I assume so.

Q22. The communications from the Patent Office came to him, and he filed the amendments or other actions in the application?

A. I don't know that there were any communica-

1924 tions from the Patent Office, except possibly receipts for the filing of papers. Mr. Swenarton, however, may have any papers that there are.

Q23. Did you or Mr. Swenarton file any amendments or other communications in said application in the Patent Office, and, if so, what were they?

> By Mr. Merwin: Objected to on similar grounds as the previous objection, that is that this improper inquiry of the witness's client's private affairs and my client in an attempt to make public the confidential proceedings in a pending application, and the
> 1925 witness is advised by me that he need not answer the questions, but await the order of the Court thereon.

A. I decline to answer until ordered so to do by the Court.

Q24. As you are the principal attorney of record, you could have obtained the papers in the application from Mr. Swenarton, if you had desired to do so, couldn't you?

A. Under an arrangement made between the attorneys, I have no personal control of the litigation or the papers in the case.

Q25. Now, please answer the question.

1926 A. I probably should have added to my last answer that I therefore could not have obtained the papers had I desired to do so.

Q26. What was the "arrangement" you mentioned in Q24?

> By Mr. Merwin: This latter inquiry has developed a degree of impropriety which might be called almost outrageous. Counsel for defendants ought to know that such inquiries are beyond the proper scope of an investigation of this kind and absolutely with-

out authority or right, on the similar grounds of objection made to similar questions seeking to make public the private and personal affairs of his and my client, and in particular the confidential proceedings in a pending application in the Patent Office, and the witness is requested to decline to answer unless so ordered by the Court. 1927

A. I decline to answer, until ordered so to do by the Court.

Q27. But you have given this "arrangement" as the reason why you could not produce the papers. I do not desire to pry into such arrangement any further than pertains to this matter. Please state, 1928 therefore, what part of this arrangement prevented you from obtaining the papers?

A. Under the arrangement referred to, I was not entitled to the papers. I knew this, but nevertheless asked Mr. Swenarton for these papers, and he refused to deliver them up.

Q28. Have you, as one of the attorneys of record in the said Mattullath application, any objection to my obtaining from the Patent Office, a copy of all papers in the file wrapper of said application since the same was filed?

A. I have. 1929

Q29. And, therefore, if I should make an application for such copies, you would oppose the same or see that it was opposed?

A. I would rely upon Mr. Swenarton's judgment in this matter.

Q30. Did you ever have in your possession or control any letters from Orville or Wilbur Wright relating to the application of Mr. Mattullath, or to his work, and, have you them now. If you have not got them now, who were they given to, for I wish to trace them?

1930 A. I did have in my possession and control a letter from Wilbur Wright, which may be said to relate to Mr. Mattullath's work. This letter is not now in my possession or control. It was delivered to Mr. Herman L. Behrens before the subpœna served upon me. The letter I refer to is the one quoted in the opinion of the Court of Appeals dated October 14, 1909, addressed to Miss Alice Mattullath, New York, and signed Wilbur Wright. I never compared the original letter with the copy included in the opinion, but I presume it is correct.

Q31. The transcript of record which you hold in
1931 your hand, on page 21 thereof, line 9, refers to certain "gentlemen whose letters I have handed to you" (it being in an amendment filed in said application). Did you ever have those letters?

A. I had a large number of letters, and I have no means of identifying the letters referred to. I have, however, no such letters now in my possession or control.

Q32. Who were they given to?

A. At the time Mr. Swenarton came into this case, which was shortly after the first argument before the Assistant Commissioner, I turned over to him practically all the papers I had, and those
1932 we did not need I turned back to Mr. Behrens.

Q33. Does this also include the letters and other documents referred to in the fourth paragraph of the subpœna?

A. Yes.

Q34. I am informed that the letters mentioned in Q31 were withdrawn from the files of the application in the Patent Office comparatively recently. If this is so, please state what you know about it, who withdrew them, and what they were, as I wish to trace them?

By Mr. Merwin: On behalf of Mrs. Mattullath to this persistent and repeated inquiry into proceedings in the Patent Office with respect to the pending application of her deceased husband, I ask the protection of the Court against the continuance of such inquiries. 1933

A. I stated in answer to Q31 that I could not identify the letters referred to, and I therefore am unable to state whether the same were withdrawn from the files, and by whom.

Q35. What do you know about the withdrawal of any letters?

Same objection. 1934

A. I have no personal knowledge of the withdrawal.

Q36. Please state what your best information is, for I wish to trace the letters?

By Mr. Merwin: Objected to as calling for hearsay evidence and the witness is not compelled to give such. He can only be required to state what is within his own personal knowledge, and this he has already stated.

A. This is information that I do not feel called upon to give, without instructions from the Court. 1935

Q37. You therefore decline to answer this question?

A. Yes, sir.

Q38. Now, Mr. O'Brien, so far as you know, did not Mr. Swenarton withdraw certain letters from the files of the Mattullath application? Please give your best information.

Same objection.

A. The letter above referred to written by Wilbur Wright to Miss Mattullath, and the letter from

1936 Barthel & Barthel to Mr. R. H. E. Starr, which appear in the Mattullath petition for revival, and also in the opinion of the Court, were filed by myself with the petition. Subsequently these same letters were handed to me by Mr. Swenarton, and by me immediately delivered to Mr. Behrens. I know nothing whatsoever of the withdrawal of any other letters. I assume these letters referred to were withdrawn by Mr. Swenarton from the files.

Q39. These two letters, having been written after the filing of the amendment which referred to the letters mentioned in Q31, are not the letters I have been asking about. Please now state your best in-
1937 formation as to the withdrawal of any letters other than the two you have just mentioned, and please understand that I want what you have been informed in regard to such withdrawal, and who informed you, whether you know anything about it directly from your own personal knowledge or not, for I wish to trace the letters?

By Mr. Merwin: Objected to, and the witness is advised that he need not and should not answer, except as to any matters that are within his own personal knowledge.

A. I have no knowledge or information as to the
1938 withdrawal of any letters, except those above referred to by me.

Q40. Have you any knowledge or information in regard to the construction or flight of any model or models of the construction illustrated in the Mattullath application?

By Mr. Toulmin: This and any similar questions is objected to, first, as immaterial and incompetent because models do not constitute reductions to practice and are not anticipatory no matter what their date, construction or performance may have been;

and second, because calling for a conclusion and secondary evidence, the model itself being the best evidence and being required by law to be produced or its absence satisfactorily accounted for, in any case where a model is admissible in evidence at all. Again, objection is made because complainant was not represented at any alleged test of any such model, and therefore cannot be bound by it. Such objections are made once for all. 1939

By Mr. Newell: I am certainly doing my durndest to find out where these models are so that they can be produced, if possible, for so far I have been unable to trace them. 1940

By Mr. Merwin: I further object because by the foregoing statement of counsel for defendants he is seeking to have this witness betray the confidence and interests of his client, and again the Court is appealed to to protect said client's interests against invasion by parties to a litigation in which he has no concern and to which he is a stranger.

A. This is a matter as to which I do not feel called upon to give any "information," until instructed so to do by the Court. I may add that I have no personal knowledge on the subject. 1941

Q41. State what your information in regard to the same is, who told you, and all you know about it, or have been informed about it, as I wish to trace the models?

By Mr. Merwin: Same objection and appeal to the Court.

A. I decline so to state, until instructed so to do by the Court.

1942 Q42. Then, until otherwise instructed by the Court, you decline to answer any further questions relating to such model or models?

A. That is correct. I desire to state, however, that such information as I have came to me as attorney for the applicant, Mrs. Meta Mattullath, in the proceeding before the Patent Office.

Q43. In order to make a clear cut question for the Court, you have some such information but on account merely of your confidential relations as attorney, you do not consider that you are called upon to disclose the same. Is that your position?

1943 By Mr. Merwin: Objected to for the reason that the question states that a declination to answer is "merely" for the specific reason stated, whereas objection is also made on behalf of Mrs. Mattullath on other grounds, and the Court is asked to pass upon that question, namely, whether this witness being one of the attorneys of record in the Patent Office for her as Administratrix of the estate of the deceased applicant, can be compelled to the obvious injury and prejudice of his client to disclose to a hostile competitor secret and confidential matters which he has
1944 and should have obtained only by reason of his employment by her as such attorney.

A. I decline to answer.

By Mr. Merwin: Upon the proposal for adjournment, Mr. Merwin as counsel for Mrs. Mattullath, states that neither he nor his partner Mr. Swenarton, who is also subpœnaed as a witness in this case, can attend the further hearing of this case until to-morrow morning, and therefore requests that the proceeding be adjourned to the earliest possible hour to-morrow morning.

By Mr. Toulmin: As I am here in New York under notice, and as this case is set for trial June 25th, I object to any such postponement as the loss of half a day. Still under the circumstances I can but yield to the request of Mr. Merwin. 1945

Adjourned to to-morrow morning, April 18th, at 10 A. M.

New York, N. Y., April 18, 1912.

Met pursuant to adjournment.

Present—Counsel as before. 1946

This day was entirely taken up by the argument of motion hereafter specified, before Judge Julius M. Mayer of the United States District Court for the Southern District of New York, respecting defendant's application to him to compel the witnesses to answer; for leave to examine the other witnesses named in the subpœna as to the same matters; and to compel the production of the papers and documents named in the subpœna *duces tecum.*

Subpœnas had heretofore been issued, one of them being a supœna *duces tecum* issued and served on 1947
W. H. Swenarton, Joseph F. O'Brien and Mrs. Meta Mattullath, requiring them to come in and testify and calling for the production of

> "1. All papers up to the present time in the application of Hugo Mattullath #751, filed Jan. 8, 1900 in the U. S. Patent Office;
>
> 2. Any letters from Orville or Wilbur Wright relating to said application or to the work of Hugo Mattullath;
>
> 3. The letters regarding the work of said

1948 Mattullath filed in the Patent Office by said Hugo Mattullath during said application and afterwards withdrawn, referred to on page 21, line 9, of the transcript of record in the Court of Appeals for the District of Columbia in the January Term, 1912, Patent Appeal Docket #751 in the matter of the application of Meta Mattullath, Administratrix of Hugo Mattullath;

4. The letters and other documents found among the effects of said Hugo Mattullath after his decease relating to flying machines and referred to on page 40 of the above tran-
1949 script of record; or such of said letters and documents as may be in your possession or control."

An ordinary subpœna was also issued and served on Herman L. Behrens and Alice Mattullath. Both of these subpœnas were returnable at this office, April 16, 1912, at 10:30 A. M.

Adjourned to to-morrow, April 19th, 1912, at 10:30 A. M.

1950

New York, N. Y., April 19, 1912. 1951

Met pursuant to adjournment.

Present—Counsel as before.

His Honor Judge Mayer rendered the following opinion:

Matter pending in

UNITED STATES DISTRICT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY

v. 1952

THE HERRING-CURTISS CO. and GLENN H. CURTISS.

In the brief time accorded for consideration of the matters herein, I am able merely to note a memorandum.

I am asked for instructions in respect of a series of questions asked pursuant to the provisions of subpœna *duces tecum* enumerated therein as 1, 2, 3 and 4.

All the parties are agreed that the defendants 1953
are entitled to any letters from the Messrs Wright referred to in Paragraph 2.

I am of the opinion that the defendants are not entitled to the information sought under Paragraphs 1, 3 and 4.

All parties are agreed that questions may be asked in respect of the Mattullath device as to whether in point of fact Mattullath actually built and operated a machine during his lifetime. I am of the opinion that the defendants are not entitled to inquire about Mattullath models built since Mat-

1954 tullath's death, entertaining this opinion after hearing the argument made before me.

The persons under subpœna are not required, therefore, to answer the questions or produce the paper writings or other documents comprehended within Paragraphs 1, 3 and 4 above referred to.

I have no objection to the defendants making such application to Judge Hazel as they may be advised and they are at liberty to say to Judge Hazel that if he so desires he may take up such application *de novo*.

In view of the convenience of the parties, however, any application I assume will be made on
1955 reasonable notice to all interested.

The conclusions arrived at by me and the rulings made by reason thereof, are based on the ground that the testimony is not enforcible from the witnesses because of privilege, since none of the witnesses are parties to this litigation and two of them are counsel for witnesses.

April 19, 1912.

(Signed.) JULIUS M. MAYER.
D. J.

And thereupon the following order was signed and filed.

1956

Order. 1957

UNITED STATES DISTRICT COURT,

FOR THE SOUTHERN DISTRICT OF NEW YORK.

In the Matter
of
THE WRIGHT COMPANY
v.
THE HERRING-CURTISS COMPANY and GLENN H. CURTISS, Pending in the United States District Court for the Western District of New York. 1958

This cause having come on, on motion of defendant to compel the witnesses, Mrs. Meta Mattullath, Herman L. Behrens and Joseph F. O'Brien, named in the subpœna to answer the questions heretofore put to them on April 16th and 17th; for leave to examine the other witnesses named in the subpœnas as to the same matters; and to compel the
production of the papers and documents named in 1959
the subpœna *duces tecum*; and the same having been argued by Emerson R. Newell, Esq., for the motion, and opposed by Timothy D. Merwin, Esq., counsel representing Mrs. Mattullath and the other witnesses, H. A. Toulmin appearing in *amicus curiea*, it is hereby

Ordered that said motion be denied on the ground that the testimony is not enforcible from the witnesses because of privilege, since none of the witnesses are parties to this litigation and two of them are counsel for witnesses, except as

1960 indicated in my memorandum opinion thereon dated April 19, 1912.

Dated, New York, April 19th, 1912.

JULIUS M. MAYER,
U. S. Judge.

And thereupon, counsel for defendant took an exception to the above ruling and order, which exception is hereby allowed.

JULIUS M. MAYER,
U. S. Judge.

Direct examination of Mr. O'Brien continued:

1961 Q44. Judge Mayer in his opinion has allowed me to ask the following question. Do you know whether in point of fact Mattullath actually built and operated a machine during his lifetime?

A. I do not.

Direct Examination Closed.

Cross examination by Mr. Toulmin:

By Mr. Toulmin: Without waiving the objections I have entered of record at this session, the witness is cross examined.

XQ45. In your investigations into the affairs of
1962 the Mattullaths, did you ascertain it to be the fact that Mr. Hugo Mattullath had lived apart from his family and in some other City than that of their residence, for some years prior to his death, and that he died away from New York, the home of his family?

By Mr. Merwin: Objected to for like reasons above stated in the direct examination, as an improper and unwarranted inquiry into the private affairs of the Mattullaths.

A. My investigations showed the facts to be as stated in the question.

XQ46. I wish you would state all that has come to your knowledge regarding an offer of $1,500 made by Mr. E. R. Newell, counsel for the defendants herein, to the counsel for Mrs. Mattullath and those claiming under her if such counsel would furnish the evidence relating to the history of the alleged Mattullath invention? 1963

By Mr. Merwin: While I do not claim to have any right to object to the question on any legal ground as affecting the interests which I represent, nevertheless I deprecate any inquiry, if it implies any reflection either upon counsel for defendants or counsel for Mrs. Mattullath, and 1964 request counsel for complainant to specify, if he is willing, whether he first learned of any such alleged transaction other than through counsel for Mrs. Mattullath or any of the parties interested with the Mattullaths.

By Mr. Toulmin: Before I had ever met any of the counsel for Mrs. Mattullath, or had ever seen Mrs. Mattullath or Mr. Behrens, or anybody else connected with the Mattullaths, I had learned of a proposition of $1,500 being proposed as coming from 1965 the defendant side of this case, but what the $1,500 was for I had not been able to learn, and did not know until Mr. Swenarton in chatting with me mentioned the fact that such an offer had come from Mr. Newell and had been rejected by himself and his associate who learned of it. This confirmed and enlarged the information I have, and I therefore have brought the matter up on this record. The answers of the witnesses will have to be depended upon to show the situation as to this mat-

1966 ter. I may add that I have never seen any of the Mattullath family, except Mrs. Mattullath when she was produced as a witness, and Mr. Behrens who has also been called. When I entered the room to attend this session there were a number of persons besides counsel, but I did not know and do not now know who they were.

A. While in Mr. Merwin's private office about ten days or two weeks ago, Mr. Swenarton came in and exhibited to myself and Mr. Merwin a typewritten agreement, and stated that Mr. Newell was in his (Mr. Swenarton's) office and had made
1967 an offer of $1,500 for our assistance in furnishing the facts in regard to the Mattullath matter. This is all I know about it, except that Mr. Merwin, Mr. Swenarton and myself discussed this proposition and refused to enter into any agreement of the character proposed.

XQ47. Did you see this typewritten agreement?

A. Yes.

XQ48. Who had prepared and brought in this typewritten agreement?

A. Mr. Swenarton stated that Mr. Newell had prepared it, and brought it in.

1968 Redirect examination by Mr. Newell:

RDQ49. Was this proposed agreement entered into, or was it rejected by the Mattullaths or their attorneys?

A. It was rejected on behalf of the Mattullaths by their attorneys.

(Signed.) JOSEPH F. O'BRIEN.

By Mr. Toulmin: As Mr. Swenarton is here present in the room and is one of the witnesses named in the subpœna, and as he has heard the testimony of the preceding

witness, Mr. O'Brien, and has also heard 1969
Mr. Newell now decline to call Mr. Swenarton, I think it proper to myself to request Mr. Swenarton, as one of the counsel for the Mattullaths and representing them, to present himself to the Notary, ask to be sworn, and then make a statement on the record as to the matter of this $1,500 proposition, as I desire the whole truth to appear. I hope Mr. Swenarton will do as here requested.

By Mr. Newell: As Judge Mayer's decision allowed me no latitude for examining Mr. Swenarton as to the Mattullath 1970
matter, except to ask him whether he knew whether Mattullath built a machine or not long before I understand Mr. Swenarton ever heard of Mattullath, it seemed hardly worth while to burden the Court with calling him, but as Mr. Toulmin has desired to learn all about the $1,500 offer, I shall be very glad to call him and Mr. Toulmin can examine him as far as he likes about it.

W. H. SWENARTON, a witness having been called by defendants, and having been sworn, 1971
testifies as follows:

By Mr. Toulmin: In the last statement Mr. Newell seems to complain of the ruling of his Honor Judge Mayer as to the scope that Mr. Swenarton might be examined under, I call attention to defendants' own witness's answer to XQ88. I refer to Dr. Zahm who under date of Nov. 16, 1911, while testifying for defendants, gave the names of a number of persons who had been associated with Mr. Mattullath. He

> 1972 named Jacob Schineller and one Loeb of Pittsburg, Prof. Coolidge of the University of Wisconsin, Prof. Thurston of Cornell University, and Prof. Harvard D. Williams, formerly of the Bureau of Steam Engineering of the Navy Department. This is ample to show that the ruling of Judge Mayer has not placed any hardship upon defendants.

Q1. Please state your name, age, residence and occupation?

A. W. H. Swenarton; 31; Montclair, New Jersey, lawyer.

1973 Q2. Do you know whether or not in point of fact Mattullath actually built and operated a machine during his lifetime?

A. If you are referring to flying machines, I will state that I do not.

Q3. Do you know where Jacob Schineller, or Prof. Coolidge of the University of Wisconsin, or Prof. Thurston of Cornell University, or Prof. Harvard D. Williams, or the one referred to above by Mr. Toulmin as Mr. Loeb of Pittsburg, live? If so please give their addresses?

A. I do not but I presume that they could readily
1974 be located by counsel, if he will make the usual inquiries customary when it is desired to ascertain the address of a person and their former residence is known.

Q4. As counsel for complainant seems to think there is something mysterious about a suggested arrangement by which I had hoped to get all the facts in regard to the Mattullath matter, please state what the offer was and whether it was accepted or not, if you know?

A. I think I can fully explain this transaction and whatever blame is to be attached to it I am willing to assume myself. Some months ago I met

Mr. Newell on the street as we went out of the 1975
building in which both of our offices are located,
No. 2 Rector Street, and casually inquired of him
how the Wright-Curtiss litigation was progressing,
for as stated to him at the time, I was interested in
the subject-matter of flying machines. In what way
I did not state. When Mr. Newell learned of the
Mattullath decision in the Court of Appeals
rendered on the first of April, 1912, and also
learned that I was one of the counsel in the
case, by telephone message from me inquir-
ing if he had seen the Mattullath decision,
he requested that I arrange an appointment
with him in my office. We discussed the bear- 1976
ing which this decision would have on the
Wright-Curtiss litigation, and he stated that he
had so little time in which to introduce evidence re-
lating to the Mattullath matter, that he would like
to know whether we would co-operate with him. I
gave him to understand that we were in a position
whereby we could doubtless render valuable assist-
ance to him, but at the same time, regardless of the
amount of money which he might be willing to pay
for said assistance, I could not state whether or
not we would be willing to assist him in any way.
It was tentatively understood, however, that if I
did assist him he was not to be required to pay 1977
over $1,500 or $2,500, the exact amount was not
at that time stated. Mr. Newell then went away
and later, I think it was the 3rd of April or the
next day, he again called me up and stated he would
like to see me at my office. He came in and brought
a typewritten memorandum of agreement in which
the amount to be paid for assistance and co-opera-
tion which we or any parties connected with the
Mattullaths could give him, was left blank and we
talked the matter over, and I told him that if Mr.
Merwin and Mr. O'Brien and myself felt that we

1978 could assist him in this matter, he would not have
to pay over $1,500. Mr. O'Brien had come over to
my office in response to a phone call by me, sent
after Mr. Newell's arrival, and so I filled in the
blank with the amount $1,500 and said I would talk
over the proposition with Mr. Merwin and Mr.
O'Brien, stating that I didn't feel we could co-oper-
ate with Mr. Newell under any circumstances, re-
gardless of the amount. Mr. Newell at that time
stated that if we preferred he might be able to get
Mr. Curtiss who had all the facilities, to build us
and give us, without expense to us, a full-sized ma-
chine built according to Mattullath's application,
1979 instead of paying us any money, in which event I
believe he indicated that some arrangement must be
made with Mr. Curtiss to give him an option of
some kind on the Mattullath invention, if he de-
sired it. I went in and showed the agreement to
Mr. Merwin and Mr. O'Brien and then came back
and told Mr. Newell that I did not think we could
assist him under any circumstances as long as our
interests were conflicting, and that it was not a
question of how much money he would pay us for
assistance, but merely the question of propriety of
rendering any assistance to him or to the Wrights
in view of the fact that they were both inimicable
1980 to our interests. I did state, however, that in
order to assure him that it was not a case of "hold-
ing him up" for money, that I would state then and
there that if we decided to assist him he would not
have to pay more than $1,500 for any services we
might render to him as counsel, or for any ex-
penses of getting witnesses which might be re-
quired for their traveling expenses or time spent,
or other legitimate expenses. He then stated "You
are satisfied then that you will not render us any
assistance under any circumstances, because you
know that we can get all the information we need

and it was merely a matter of legal procedure and 1981
expenditure of time to enable us to get it." I told him I appreciate the fact and that we felt that for us to at this time cooperate with him or with the Wrights and to divulge secret information possessed by us, would work irreparable injury to us, or words to that effect, which no amount of money that I believe Curtiss could afford to pay would compensate for. He then, or within the next day or two, stated "Is there not some way by which we could get together, referring to the Mattullath and Curtiss interests, or, as he stated it, Curtiss had always taken an attitude which was entirely con-
sistent with his now tying up with the Mattullath 1982
interests, whereas in his opinion the Wright Company had always taken an entirely inconsistent attitude respecting this Mattullath invention. I told him that to my mind that it was merely a question of what the proposition was which his parties were willing to make, and that if the Curtiss interests secured an actual interest in the Mattullath invention, there should of course be then no impropriety in the union of the interests in so far as this defense of the Wright suit was concerned. There was nothing more ever done about the matter, except that prior to issuing these sub-
pœnas Mr. Newell once more inquired whether 1983
we were going to remain passive, or whether we were willing to volunteer the information he desired. Whatever amount of money was talked of or proposed, was in my opinion not intended by Mr. Newell as a bribe or as a payment to obtain information in an unprofessional way, but rather as a payment to secure the services of Mrs. Mattullath's counsel and to enable them to save the expenditure of time and money in making models or taking testimony which they would be compelled to take if we were not willing to render such assis-

1984 tance as he desired. As a matter of fact, as I
remember it, I first told him that if we cooperated
with him we would not consider anything less than
$2,500 in cash, but even if this payment was ten-
dered I could not state positively whether we would
be willing for the sake of assisting in defeating
the Wright suit, to cooperate with him and would
have to discuss the matter with the other counsel
in the case. Mr. Newell, so far as I recollect it,
desired that we render the assistance voluntarily,
without any payment whatsoever by them, for the
purpose of uniting against the Wright interests,
and it was upon my refusal to spend the time
1985 which such assistance would require on my part or
Mr. Merwin's part or Mr. O'Brien's part without
remuneration, or to give him the necessary ad-
vice which we believed is in our power to give him
concerning the conduct of this defense, that he in-
quired as to what amount we believed to be proper
for rendering such cooperation. It was in this way
that the question of any payments whatsoever
arose, and as stated that if there are any reflections
to be cast upon anyone, it should be cast upon me
for presuming to request remuneration for profes-
sional services which would be commensurate
with what I was charging to any other par-
1986 ties desiring equally valuable assistance in such
matters. I might further add that I stated in ef-
fect to Mr. Newell at this time that one of the
reasons why we felt we could not, regardless of
the amount involved, voluntarily cooperate with
him and not stand pat on our legal rights, was be-
cause as between the two parties we, if anything,
would prefer that the Wrights succeed in this suit
in obtaining an adjudication that the Curtiss aile-
rons were the equivalent of the Wright warping
mechanism, as in that event since the Mattullath
ailerons were substantially identical with the Cur-

tiss, and that it would then be conversely true that 1987
the Wright warping mechanism was the equivalent of the Mattullath movable stabilizing planes or ailerons. In response to a question off the record by Mr. Toulmin as to whom this money was to be paid to, I would state that I specifically told him (Mr. Newell) that this money was not to be paid entirely to the attorneys but was to be paid to the Mattullath interests to reimburse them for any expenses they might have in connection therewith, and that whether or not they would pay us out of this money was for the determination of the Mattullaths if it was decided that they could,
with propriety, enter into any such arrangement. 1988
As stated, the whole arrangement was flatly refused at any price, after consultation with Mr. O'Brien and Mr. Merwin.

Q5. And within a day or two after such refusal, the subpœnas were served upon you and the others?

A. Yes, a few days, I couldn't say just how many, it was on the 13th of April, 1912.

By Mr. Toulmin: No cross examination, it appearing from the record that Mr. Swenarton was requested by me to make a statement. 1989

W. H. SWENARTON.

It is hereby stipulated that if Mrs. Meta Mattullath and Herman L. Behrens, witnesses heretofore called, and Miss Alice Mattullath also under subpœna, were called and the question were asked them whether they knew in point of fact whether Mattullath actually built and operated a machine during his lifetime, they would reply that they did not know anything about it.

It is further understood that they are now

1990 discharged, as counsel for complainant does not care to cross examine.

It is hereby agreed that the following letter from Wilbur Wright, dated Oct. 14, 1909, is a copy of the original letter subject to correction if error shall be discovered, and that the original letter need not be proved.

"College Park, Maryland,
14 October, 1909.

Miss Alice Mattullath, New York.

Dear Madam:—

1991 I thank you for your very kind letter of 29th Sept., which I have found it impossible to answer hitherto. I had already arranged a canoe to float the machine in case of coming down, so could not try the raft you were so kind as to suggest and offer, but I very much appreciate the friendly spirit which prompted you.

I knew a little of your father's work through conversation with Professor Zahm and others, but he had died before my brother and I had really begun our work.

1992 With many thanks and best respects,

Yours truly,

WILBUR WRIGHT."

By Mr. Newell: In view of the opinion by Judge Mayer above quoted, I hereby give notice to all parties that on Monday, April 22, 1912, at 10:30 A. M., in the Court-room in Buffalo, New York, or in Judge Hazel's Chambers, I shall move the Court for an order the same as the motion made before Judge Mayer, and for such other relief in the premises as the Court may grant.

It is agreed that as counsel for defendants has already wired Captain Beck, if he receives word to-morrow that he can take Captain Beck's testimony in Washington on Monday, he will wire Mr. Toulmin and Capt. Beck may be put on on Monday, in which case the motion will be postponed until further notice or agreement. 1993

Adjourned at 6:15 P. M. as per the above.

Magistrate's Certificate.

UNITED STATES DISTRICT COURT, 1994

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY *v.* THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.	In Equity No. 400.

I, Beatrice Mirvis, a Notary Public in and for the County of New York, do hereby certify that pursuant to notice issued and served in the above mentioned cause, I was attended at the office of Emer- 1995
son R. Newell, No. 2 Rector Street, New York City, New York, by H. A. Toulmin, of counsel for complainant, Emerson R. Newell, of counsel for defendants, and Timothy D. Merwin, counsel for the witnesses hereafter mentioned, on the several days and dates stated in said testimony; that the witnesses named therein, viz.: Mrs. Meta Mattullath, Herman L. Behrens, Joseph F. O'Brien and W. H. Swenarton, who were of sound mind and lawful age, were by me first carefully examined and cautioned, and duly sworn to tell the truth, the whole truth and nothing but the truth, and they

1996 thereupon testified as above shown; that the depositions as above set forth were by me reduced to writing in the presence of the witnesses themselves and from their statements, and were subscribed by witnesses O'Brien and Swenarton, but the depositions of said Meta Mattullath and said Behrens were not subscribed by them as they did not appear after the session at which their testimony was taken, at which time their testimony was adjourned; that said depositions were taken at the places indicated and at the times set forth, adjournments being had and taken from day to day as indicated; that all was so done, written and
1997 signed in the presence of said counsel for complainant and for defendant and for said witnesses. I further certify that the reason for taking said depositions was and is, and the fact was and is, that all of the deponents lived and do now live more than a hundred miles from the place where said Court was sitting, and said suit is appointed by law to be tried; that I am neither of counsel nor attorney to either parties to said suit, nor interested in the event of said cause; and that it being impracticable for me to deliver said depositions with my own hand into the Court for which they were taken, I have retained the same for the purpose of
1998 being sealed up and directed by own hand and speedily and safely transmitted to the Court for which they were taken, and to remain under my seal until then opened. I further certify that my fees for taking said testimony amounting to twenty dollars ($20.00) have been paid by defendants.

Witness my hand and official seal at New York City, New York, this 14th day of May, 1912.

BEATRICE MIRVIS,
[NOTARY SEAL.] Notary Public, No. 160,
N. Y. Co.

Order. 1999

UNITED STATES DISTRICT COURT,

FOR THE WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY *v.* THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.	In Equity No. 400.

This cause having come on on motion by defendants to review the order of Judge Julius M. Mayer, dated April 18, 1912, in view of Judge 2000 Mayer's suggestion in his opinion of the same date that the matter might be taken up to move by Judge Hazel, and on motion by defendants that this Court indicate that the defendants' said motion before Judge Mayer should have been granted, and the record since April 15th having been considered, and the motions having been argued by Emerson R. Newell, Esq., for the motion, no one appearing against the motion, and H. A. Toulmin merely appearing *amicus curiae* and not objecting thereto,

It is ordered that said motions be denied on 2001 the ground that this Court is without jurisdiction in the matter.

April 22, 1912.

JOHN R. HAZEL,
U. S. J.

Objection and exception to the above ruling and order was then taken by counsel for defendants, which exception is hereby allowed.

April 22, 1912.

JOHN R. HAZEL,
U. S. J.

2002 UNITED STATES DISTRICT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY
v.
THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.

In Equity No. 400.

Washington, D. C., April 27, 1912.

Met at 10 o'clock, A. M., at the office of Meyers, Cushman & Rea, in the McGill Building, Washington,
2003 D. C., pursuant to notice, for further testimony for defendants, under the 67th Rule and Statutes, before Miss Gertrude M. Stucker, Notary Public, pursuant to permission by the Court.

Present—Mr. H. A. TOULMIN, for Complainant.
Mr. E. R. NEWELL, for Defendants.

PAUL W. BECK, a witness called on behalf of defendant, and having been heretofore sworn, testified as follows in answer to questions put by Mr. Newell.

Q1. You are the same Captain Paul W. Beck
2004 of the United States Army, who has heretofore testified in this case?

A. I am.

Q2. Some of the witnesses for complainant, on rebuttal, including Lieutenant Arnold and Lieutenant Kirtland, spoke about a letter which they said you had shown them, and which you received from Mr. Curtiss. Have you the original of that letter?

A. So far as I can find, I have not.

Q3. Please explain what became of it, if you know, and whether you have made any search to find it, and if so, what efforts you have made.

A. When the letter was received by me at Augusta, Georgia, I read it to Lieutenant Milling in compliance with the request of Mr. Curtiss, in said letter. This was in the presence of Lieutenant Arnold and Lieutenant Kirtland. The letter passed from hand to hand, and the four of us discussed it in its various phases. It is my impression that I then put it in my desk at the aviation field in Augusta, but a diligent search later on failed to discover it. I then looked through my papers at the house in the City of Augusta, but was unable to find it. As a matter of fact, I do not know what became of the letter. 2005
There was a flood while we were in Augusta, which caused considerable confusion at the field; things were moved to places of safety, and papers were moved about, and it may be that the letter was lost at that time. It may also be that the letter was burned, since I have a habit of cleaning out my desk occasionally, and this letter did not appear to me to be particularly important after the discussion I had with the other officers. 2006

Q4. I show you here a carbon of a letter and ask you whether you recognize it, and what it is.

A. This appears to be a copy of the letter previously referred to. 2007

The copy to which witness refers reads as follows, and is copied in the record instead of being formally offered as a separate letter:

Copy.

Coronado, Calif., February, 1912.

Capt. Paul Beck,
Augusta, Ga.

Dear Capt. Beck:

I hope by this time everything has been

2008 satisfactorily arranged for the delivery of the new aeroplane. We have just learned that Lieut. Milling has been on the stand at Dayton and testified that he has flown our machine and that it is necessary to use a rudder to counteract the turning effect caused by a difference of resistance caused by the ailerons.

The Wrights are evidently attempting to make it appear that turning the rudder toward the high side to assist the ailerons in balancing a machine is the same as counteracting a turning effect of the ailerons.

2009 It must be a well known fact that an aeroplane can be balanced entirely by steering and that practically in all the machines except the Wright's it is customary for the aviator at times to assist in balancing the machine by steering or turning it with the rudder to increase the speed of the low wing and decrease the speed of the high wing. Assisting the action of the ailerons is entirely different thing from counteracting an effect of the ailerons.

The ailerons never cause a turning effect which we counteract with the rudder, but a
2010 turning effect might be caused by the rudder to assist the ailerons. A machine may also be steered entirely by banking, but this is not a case of one aileron giving more resistance than the other.

I am referring to these matters so that you can explain, if you will, to Milling, or whoever might be called upon to testify, so that they will not be lead to believe, as Milling evidently has been, that in turning the machine by the rudder to assist the action of the ailerons, that he is doing it to counteract a turning effect of the ailerons.

Let me know if you understand this as I do and what Wilbur Wright has to say about the patent situation. 2011

Yours truly,

(Signed.) G. H. Curtiss.

GHC—OD

Q5. Is that the letter which you referred to and talked over with Lieuts. Milling and Kirtland?

A. It is the letter which I showed to Lieut. Milling, and talked over with Lieuts. Milling and Arnold, in the presence of Lieut. Kirtland.

Q6. In the Government-owned machines which you have flown of the Curtiss type, where are the ailerons located? 2012

By Mr. Toulmin: This, and any similar question, is objected to on the ground that it is an attempt to reprove defendants' case as distinguished from a recall of Capt. Beck to explain matters connected with the letter referred to. This objection is made once for all to such line of examination.

By Mr. Newell: The order permitting the recalling of the witness merely stated that the witness might be recalled.

By Mr. Toulmin: Yes, but the showing and statements made to the Court had reference to the production of the letter in question, or an explanation concerning it by recalling Capt. Beck. 2013

Mr. Newell: That was only one of the reasons.

A. The front edge of the ailerons are attached on a line with the rear vertical posts.

Q7. Please estimate about how often you have flown such machine.

A. Do you refer to all Curtiss machines which

2014 I have flown, or only those which are owned by the Government?

Q8. Answer as to the Government-owned machines.

A. I have probably made about two hundred flights in the Government-owned machines of the Curtiss type; certainly not less than one hundred and fifty.

Q9. Please state the duration of your longest flight.

A. The longest flight I ever made was in a machine owned by the Government, Curtiss type machine, 1 hour, 1 minute.

2015 Q10. About how many miles did that cover?

A. About sixty-one.

Q11. Lieut. Milling has stated substantially that in the flying Government-owned machine, he always turned his rudder toward the high side when restoring balance. Has that been your experience?

A. It has not. In regaining balance on a straight-away flight, I roughly divide the acts into three distinct phases. In the first phase, where the lack of balance is small, I should say not to exceed a difference of a foot, to a foot and a half between the extremity of the high and low wing, I regain balance by use of the ailerons alone. The
2016 second phase is where one wing is enough higher than the other to cause fear that the machine may slip off sideways, and yet such slip has not actually started. In this case I not only bank, by use of the ailerons, so as to bring up the low side, but I turn my rudder toward the high side in order to change the direction of flight,—by changing the direction of flight I mean causing the machine to turn toward the high wind—thereby causing the low wing to move faster than the high wing, which has the effect of bringing the low wing up to the same elevation as the high wing. The third phase is

where a side slip has actually occurred. After 2017
this once starts, it is practically impossible to
regain equilibrium by the method used in the second
phase. In this third phase, the ailerons are actu-
ated toward the low side in order to bring the wings
vertical. At the same time the rudder is turned to-
ward the low side. The effect of this is to first
cause the aeroplane to drop with the wings per-
pendicular to the earth until the air catches the
rudder, which has now assumed a horizontal posi-
tion, and is therefore serving as an elevator. This
produces a rotation of 90 degrees in the entire ma-
chine and points the nose downward. With the
nose once pointed downward control can be re- 2018
gained by use of the elevator, or normally hori-
zontal rudder.

I have actually seen a machine brought out of this dangerous predicament in this way. In my opinion, based on this incident, it cannot be successfully executed from a less elevation than 300 feet.

Q12. Such uses of the normally vertical rudder are in each case to turn the machine itself, are they not?

Mr. Toulmin: Objected to as leading.

A. Yes, sir, in every case in which I have had 2019
to use the vertical rudder to assist in regaining
the lateral stability, I have used it to change the
direction of the machine in order to increase the
speed of the low wing.

Q13. When the ailerons are used is there any turning of the machine detectable, caused by the ailerons themselves?

A. I have never detected the slightest turning tendency in the standard 50 horse-power Curtiss aeroplane due to the use of the ailerons alone.

Q14. In making a turn, what do you use first, 2020 the vertical rudder or the ailerons if you desire to bank the machine.

A. I normally make my turns by first using the vertical rudder, and then almost immediately leaning toward the inside of the turn to produce a bank by means of the ailerons.

Q15. Would a person be correct in stating that you always had to use your vertical rudder in restoring lateral balance in the Curtiss machines you have flown?

A. No, such a statement would not be correct. It is a perfectly reasonable thing, however, to suppose that an individual in the vicinity of the aviation
2021 field might get that idea, because all the turns made near the field are of necessity acute turns, and in acute turns the rudder and ailerons are almost always in conjunction. However, this use is to add to the turning effect and not to reduce the turning effect of the rudder. There is no turning effect caused by the ailerons. What I mean here is that the rudder and ailerons are both working in the same direction, and are not working against each other, and the turning effect I allude to is the change of direction of the machine in a horizontal plane.

Q16. Do you mean that the ailerons themselves
2022 produce a turning effect?

A. No, I mean that the ailerons are used to bank the machine when the rudder is thrown in to produce the turning effect, both the bank due to the ailerons and the turning effect due to the rudder being used to change this direction of the machine. The bank is to prevent the side skid, and the rudder is to attain the change in direction.

Q17. When you use the vertical rudder at the same time as the ailerons to restore balance, you always turn the rudder toward the elevated side of the machine, if I understand you correctly?

A. Yes, except in the third phase mentioned above; and furthermore, whenever I am compelled to use this rudder to assist in gaining lost lateral equilibrium, I change the direction of flight of my machine. This new direction is toward the high side of the machine. 2023

Q18. You have been in charge of the Government-owned Curtiss machines?

A. Yes, I have been in charge of them ever since July, of 1911, when the first one was purchased.

Q19. Referring to the Curtiss machine which Lieut. Milling flew, did you, prior to his flights, do anything to the so-called equalizer, and if so, what?

A. I made no direct change in the equalizer, but I lengthened the aileron wires which connect with the bottom of the ailerons, so as to leave them slack when the ailerons became neutral to the line of flight. This had the effect of throwing the so-called equalizer completely out of operation, and was done for the purpose of reducing the drag or resistance of the machine while in flight. When received by me from the Curtiss factory, this so-called equalizer was in operation, and the wires connecting it with the lower sides of the ailerons were taut which gave the ailerons a permanent droop of about one inch when in flight. 2024

Q20. Then the equalizer device was not in proper working condition at the time Lieut. Milling flew it, is that correct? 2025

A. Yes, sir, that is correct. The equalizer was not in operation at any time Lieut. Milling flew this machine.

Cross examination by Mr. Toulmin:

Without waiving the objections of record, cross examination proceeded with.

XQ21. Did you tell Lieut. Milling that you had

2026 made any changes in the Curtiss machine, such as you have just stated, before you allowed him to take the machine up in flight?

A. No, sir, I never told him anything about it.

XQ22. How many Government-owned Curtiss machines were at the aviation field near Augusta?

A. There were two; one standard 50 horse-power machine, and one large surface, school, 40 horse-power machine.

XQ23. Did Lieut. Milling fly both of these machines?

A. No, sir. He never flew the standard machine. He did fly the school machine which has
2027 larger surface than the standard, with the standard 50 horse power motor in it.

XQ24. The effect of the ailerons being in the drooped position before you lengthened the lower wires would be to increase the difference in the angles of incidence of one aileron compared with the other when they were adjusted through equal movements, would it not?

A. Yes, undoubtedly that would be the effect.

XQ25. And this Curtiss machine came from the Curtiss factory so as to be organized in the manner you found it, with the ailerons slightly drooped below a so-called normal, is that correct?

2028 A. That is correct.

XQ26. Referring to your so-called second phase of operating the Curtiss machine, you say that you change the course of the machine by turning the rear vertical rudder toward the high side. Would it not be more correct to say that by so turning the rudder you prevent the high side from travelling faster than the low side?

A. I hardly think so, because there is always in this phase a decided change of direction due to the introduction of the vertical rudder.

XQ27. Then if you did not turn the rudder toward the high side, the machine would proceed out of its course toward the lower side, would it not? 2029

A. Undoubtedly in this second phase, there is decided danger that the machine will slip off sideways, and on that account I habitually throw the rear vertical rudder into operation so as to increase the speed of this lower wing, and prevent the side slide. I do not think that there is any tendency to change direction toward the low side due to the bank of the ailerons alone.

XQ28. You say that you turn the rear vertical rudder, under these conditions, toward the high side, and change the course of the machine toward the high side. Would it not be more correct to 2030
say that by so using the rudder with the ailerons you not only recover lateral balance, but you keep the machine going ahead in substantially its original course as distinguished from diverting it off from the high side?

A. No, sir; I do no agree with that. It has been my experience that whenever I have been necessitated to use the rudder in regaining lost lateral stability, I have had to use it to such an extent as to manifestly change my direction of flight.

XQ29. When, under the condition of phase No. 2, you turn the rear vertical rudder toward the 2031
high side, there comes into play head pressure on the side of the rudder which is toward the high wing, while at the same time, there is head air pressure on the upturned aileron which is at the high side. That is correct, is it not?

A. Yes, sir; but at the same time there is corresponding head pressure on the downturned aileron of the low wing, but I have testified that at the same time I turn my rudder I also actuate my aileron so as to reverse these pressures to which you allude. Thereby adding to the lift caused by this change of pressure on the ailerons, 2032 I have the increased speed caused by the change of direction produced by the rudder.

XQ30. The last sentence of your preceding answer seems to introduce a complication not introduced in your answer concerning the second phase in your direct examination. To avoid confusion, let me ask you one thing at a time. Under the conditions of your second phase of operation, you set the ailerons on the low side to a lifting angle, and the aileron on the high side to a depressing angle, and while the ailerons are in these positions you turn the rear vertical rudder toward the high side. So far is this correct?

2033 A. Yes, sir; that is exactly what is done.

XQ31. And when things are just as stated in the last question, there is a lifting action at the lower side of the machine, a depressing action at the high side, both accompanied by head pressures acting on the ailerons. Is that correct?

A. If by head pressure you mean a pressure from the front, that is correct.

XQ32. And while these two head pressures are existing, accompanied with the lifting pressure on the low side, and the depression on the high side, the rear vertical rudder is swung over to the high side and offers a head pressure on its sur-
2034 face, which is toward the high side. Is that correct?

A. Yes, that is also correct.

XQ33. And you utilize this operation in what you have termed the second phase, whenever the Curtiss machine has been tilted more than enough to cause the higher side to be in excess of a foot and a half above the lower side, or substantially so. Is that correct?

A. This is substantially correct. It is, of course, impossible to give these differentiations between the three phases in absolute feet and

inches, because they are so variable; sometimes a 2035
variation of six inches is dangerous, where at other times a variation of two feet is safe, but your statement is substantially correct, yes, sir.

XQ34. Then, as you did not observe any turning of the rear vertical rudder toward the high side in the tests made by Mr. Curtiss at North Island, to which you refer in your other deposition, the tilting of the machine in those tests was such as would come within your first phase of the operation. Is that correct?

A. Yes, sir. It undoubtedly was.

Redirect examination by Mr. Newell: 2036

RDQ35. When you receive a machine from the Curtiss factory, is the machine set up ready to fly, or is it taken apart, and has to be put together after it is received?

A. The machines from the factory always come knocked down in two or three crates or boxes. Sometimes the actual control wiring is not soldered, but there are surplus lengths of wire. This is because most pilots or aviators prefer to adjust their own controls. I do not now remember whether or not this particular machine was soldered when received. What I do remember
is that the first time I tried to fly the machine, 2037
I found this constant droop, and since the motor was not working very strong I took the droop out in order to give the machine all the possible chance it could have by avoiding head resistance.

(Signed.) PAUL W. BECK.

ALBERT F. ZAHM, heretofore introduced by defendants, being recalled, testifies as follows in answer to questions by Mr. Newell:

Q1. Are you the same Albert F. Zahm who has heretofore testified for defendants?

2038 A. Yes, sir.

Q2. You have heretofore testified that you are acquainted with Mr. Mattullath's work, and helped him prepare his application which has been introduced in evidence. If you made experiments with Mr. Mattullath during his lifetime, please state what they were and where conducted.

> By Mr. Toulmin: I object once for all to
> any questions concerning matters which
> were within the knowledge of this witness
> when he testified heretofore. The question
> just given is of that kind. I also object to
> 2039 any testimony concerning these experiments
> as experiments are of no consequence as
> such.

A. They were conducted in a specially erected
laboratory at the Catholic University of America
during the years 1901 and 1902. The experiments
were of two kinds. First, determinations of air
resistances on the various forms of surfaces to be
employed in constructing an aeroplane; second,
experiments in structural design. The experiments
in structural design included the building and test-
ing of models of the proposed surfaces; particu-
larly the proposed sustaining surfaces; models of
2040 the beams and posts to be employed to secure the
greatest strength with the least weight; and a
large model of the propeller invented by Mr. Mat-
tullath.

Q3. Over about how long a time did these experiments extend?

A. Nearly two full years.

Q4. Did Mr. Mattullath have any other business at this time, so far as you know, or did he keep at the development of his flying machine?

A. He labored on it almost continuously without cessation, either of his own efforts or those of his numerous assistants.

Q5. And did he endeavor to interest capital in his invention? 2041

A. He had invested capital before the experiments began, but the experiments were made at the expense of persons to whom he had explained his invention.

Q6. So far as you know did Mr. Mattullath have means of his own, or did he have to rely upon capital furnished by others to conduct his experiments?

A. His own resources were practically exhausted when the experiments began. He worked on a salary paid by the interests promoting his invention, and not all the expenses of the mechanicians and 2042
several assistants from funds supplied by the company, so far as I am aware.

Q7. Until the time when he died, in 1902, did he give up the prosecution of his invention?

A. On the contrary, he was actually at work preparing a statement of results to be presented to his council of engineers as preliminary to building the large machine with their endorsement.

Q8. You spoke during a former deposition of Prof. Thurston. Is he alive now, and if not, about when did he die?

A. He died a few years after Mr. Mattullath's death, as I remember. 2043

Q9. Your equalizer application has been introduced in evidence by complainant at the end of its rebuttal testimony. In said application you show drawings of a machine having ailerons somewhat like defendants' machine. Did you, by any expressions in regard to the operation of said machine, intend to state that that machine you illustrated would necessarily have a turning given to it by the use of the ailerons? Also explain, please, what you meant.

By Mr. Toulmin: Objection is made once

2044 for all to any such line of examination. Dr. Zahm was on the witness stand for defendants when the matter of such application was brought out on the record by cross examination, and if he had any explanation to make it should have been made then, or on the redirect. Dr. Zahm resisted the production of a copy of said application until the Court compelled him to allow such copy to be produced. In reopening this case, the Court did not intend the witnesses as to the Mattullath affair, of whom Dr. Zahm was to be one, to go outside of such matter. To
2045 now endeavor to get Dr. Zahm to qualify the meaning of his application as formerly stated under his oath, is therefore objected to.

By Mr. Newell: Dr. Zahm's application was introduced long after Dr. Zahm left the stand, and if I recollect correctly, the matter of his application was given as one of the reasons before the Court when application was made to recall him among the other witnesses.

By Mr. Toulmin: I know of no presentation to the Court of any reason for re-
2046 calling Dr. Zahm, except that relating to the Mattullath affair. That Dr. Zahm's application was introduced in evidence in rebuttal is no reason why he could not have explained its meaning if he had any explanation to make at the time it was referred to on the cross examination. It is therefore clear that the present attempt to explain away such application is an afterthought, and an effort to avoid the position Dr. Zahm is in on this record as shown by comparison of his testimony and the contents of said application.

By Mr. Newell: But when Dr. Zahm was on the stand the matter of his application was brought out for the first time on his cross examination and objected to then, and he was not on the stand when it was introduced. 2047

A. My patent application was intended to be as general as possible, and not intended to refer specifically to the machine shown in the patent drawing, and not intended to assert that the particular symmetrical machine shown in the drawing would suffer any torque whatever about the vertical axis when controlled with the ordinary unbalanced ailerons. 2048 The particular drawing of the patent was copied for convenience from a well-known print, and serves the purpose of a general application.

As stated in my answer to RDQ132, I apprehended:

> "that in the most general case of any aeroplane whatever, whose lateral balance is maintained by stabilizing surfaces at either side of the machine, there might be an objectionable torque about the vertical axis due to the peculiar design or mode of operation of such an aeroplane," 2049

and I wished the patent application to cover all cases of this kind. This application was signed after my first computations, made on behalf of defendant, showing that there may be, under certain assumed circumstances, a minute turning tendency about the vertical axis when the ailerons are worked. I requested my patent attorney to word the preamble of the application with these points in mind. If any expressions in the preamble seem to contain an assertion that a substantial or objectionable torque about the vertical axis is exerted

2050 by the ailerons in a symmetrical machine identical with the defendants', such expressions do not clearly convey the ideas I wished to express, and do not bear out the spirit of my instructions to the patent attorney in drafting the application.

By Mr. Toulmin: I wish to put on the record that during the giving of the above answer, witness had before him and was referring to his former testimony in this case.

Q10. This application was prepared and signed long before you made the experiments in Hammondsport last Summer which you have heretofore
2051 testified to, was it not?

A. Yes, sir.

Q11. Do you consider that what you have said in your application contradicts, in any way, the spirit of your testimony which you have given in this case.

By Mr. Toulmin: Objected to as calling for an afterthought, as well as for a conclusion as to which the Court alone is competent to state.

A. No.

2052 By Mr. Newell: I wish to ask the witness to comment on the computation made by Capt. Chandler during the rebuttal testimony. I realize that this is not within the scope of the permission given by Judge Hazel as to this present testimony. I neglected to speak about this when we were before Judge Hazel, but as the witness is present, and in order to save another trip to Buffalo and motion before Judge Hazel, and a trip back again to Washington, Mr. Toulmin and I have talked the matter over,

and he consents that I may thus proceed 2053
but without prejudice to his rights and subject to such objection as Mr. Toulmin may make at the hearing in order that the Court may then pass on whether it would have granted permission to ask this question or not. I make this statement because otherwise I would not ask the question without applying to the Court for leave to so ask it.

Q12. You, this morning, looked over the deposition of Captain Chandler for the complainant, in which he made certain computations as to theoretical differences of resistance on ailerons standing at the angles used in our experiment last 2054
Summer with the hydro machine in Hammondsport. Aside from the fact that he did not use the shaped ailerons which we used, nor the same density of the air, please criticise his method of obtaining the results which he computed, and show why, if it be a fact, the difference which he found would not be even theoretically correct under the conditions of the experiment on the lake.

A. I have glanced over Captain Chandler's computations hurriedly, and find less objection to his numerical results than to their application in criticism of the experimental determination 2055
which I made of the resultant turning effect of the pair of ailerons mounted on the king post in the lake experiments referred to.

The king post when the hydroplane was in steady motion was oblique to the true plumb line, vertical, and served as an axis of rotation for the attached ailerons, should one exert a greater torque than the other. The spring balance employed measured the resultant torque, not about the plumb line axis, but about the king post axis, and from this was computed the component of the resultant force on the two ailerons resolved perpendicularly to the direction of the king post

2056 axis. This force was found to be 65/100 lb. Captain Chandler computed the resultant force of the wind on the two ailerons to have a component perpendicular to the plumb line axis equal to four pounds, approximately. The two results are different, but they have not been proved to be inconsistent one with the other.

It is important to observe that not only the horizontal component of the wind force computed by Captain Chandler, exerts a torque about the king post axis, but the vertical components of the wind force also exert powerful torques about that axis, and these latter have been left out of
2057 consideration entirely by him and by Mr. Wright.

The vertical component on the down-turned aileron tends to neutralize the effect of the horizontal component on said aileron, one tending to turn the king post positively, the other tending to turn it negatively. On the upturned aileron, on the contrary, the horizontal component conspires with the vertical component, both tending to turn the king post in the same direction. If these facts be taken into consideration, and if a correct theoretical analysis of my experiment be made, it will be found that my measurements are much nearer even to a correct theoretical estimate of
2058 the resultant component force of the wind tending to turn the ailerons about the king post, than is the erroneous theoretical computation of Mr. Wright. Mr. Wright's error consists, not so much in the coefficients employed, as in the method of resolving the forces, a method about which no two persons can disagree who clearly understand the analytical conditions. I criticise not so much his use of physical coefficients, which seem somewhat excessive, as his unskillful use of the well-known principles of mechanics.

There can be no question about the obliquity

of the king post; this was determined by a well- 2059
known method practiced by investigators in aerodynamics for determining the direction of flow of air by means of a fine silk thread floating near a graduated arc. The end of the silk thread extended some distance beyond the graduated arc and fluttered slightly, but the body of the thread near the graduations was quite steady when the apparatus was moving over the level lake at steady speed.

To summarize my technical statement in simpler language, I will say that Captain Chandler and Mr. Wright, in estimating the resultant torque
produced by the ailerons about their axis of ro- 2060
tation, should have computed both the lift and drift on each aileron, and then have estimated the torque produced by the lift as well as by the drift. They should have added together those torques which conspired, and should have subtracted those which acted oppositely to each other. The entire sum of the positive and negative torques would then have given a theoretically true resultant torque. From this they could have obtained the theoretically true wind force acting about the axis of rotation if so desired, but this they did not do. A simpler method, of course, is
to resolve the wind force in directions parallel 2061
and perpendicular to that of the king post.

Cross examination by Mr. Toulmin:

XQ13. Regarding the Mattullath experiments, were you paid out of the funds you refer to for assisting Mr. Mattullath in those experiments?

A. I was not paid a regular salary, but I received some slight compensation for some vacation work perhaps, and I also advanced Mr. Mattullath several hundred dollars of which we kept no very strict account. On the whole, the compensation for any work I may have done was but a trivial

2062 one; my main interest lay in the physical researches being made.

XQ14. Did you lose the several hundred dollars advanced, or was the amount returned to you?

A. I should say that I did not lose, on the whole.

XQ15. Well, was the money returned to you?

A. As I remember, the bulk of it was returned to me.

XQ16. Who by?

A. By Mr. Mattullath.

XQ17. In 1903 did you write a letter to Mr. H. L. Behrens, son-in-law of Mrs. Mattullath,
2063 stating that you did not know of Mr. Mattullath having any patents on flying machines, and that so far as you know there was nothing of value left by Mr. Mattullath?

A. I do not think that those precise words were used.

Adjourned to day after tomorrow, Monday, April 29, 1912, at 9:00 o'clock, A. M.

Washington, Monday, April 29, 1912.

Met pursuant to adjournment.

2064 Present—Counsel as before.

XQ18. Well, you wrote such a letter and substantially so stated, did you not?

A. As I remember my reply it may have conveyed the impression that Mr. Mattullath left nothing directly saleable, or that could be converted into ready money, excepting, of course, his bank account.

XQ19. But I did not ask you to now interpret your former letter. Please, therefore, state whether in fact you did write such a letter to Mr. Behrens stating in substance that so far as you knew, there was nothing of value left by Mr. Mattullath. 2065

A. As far as I recall my letter, I replied that there was nothing left that was saleable or convertible into ready money.

XQ20. The letter from Mr. Behrens to yourself, to which your letter was a reply, asked you for information regarding the alleged flying machine invention of Mr. Mattullath, did it not?

A. It may have made such inquiry, but I do not recall distinctly the exact nature of the question.

XQ21. Mr. Mattullath died in December, 1902, as you have stated. And it was in January, 1903, the month following, that Mr. Behrens wrote you 2066
for information regarding Mr. Mattullath's alleged flying machine invention. And your letter to Mr. Behrens was intended to inform him as to what you thought Mr. Mattullath had left in regard to a patent on the flying machine, or the flying machine invention. Is not that correct?

> By Mr. Newell: The date of the letter referred to by Mr. Toulmin is objected to, as it does not appear that such was the date.

A. I do not remember the date of the letter, and I have but a vague recollection of the contents of my reply to Mr. Behren's letter, as it was written 2067
more than nine years ago; nor do I recall the date of my reply.

XQ22. Do you not remember that your reply was shortly after the death of Mr. Mattullath?

A. As nearly as I can recall, the reply was some time in the year 1903.

XQ23. Then the matter of whether Mr. Mattullath left a flying machine patent, or any invention relating to flying machines, and the value of the same, was fresh in your mind at that time, was it not?

A. I should say so.

2068 XQ24. Then in 1909 you went to an attorney in Washington who had a power of attorney in the Mattullath application, then in an abandoned state before the Patent Office, and obtained from such attorney written authority addressed to the Commissioner of Patents authorizing you to inspect the Mattullath application, did you not?

A. Yes. I was writing a treatise on Aerial Navigation and I asked Mr. Bacon, Mr. Mattullath's former attorney, to secure for me permission to look at the file wrapper as I had prepared for application a description of Mr. Mattullath's aeroplane as I remembered it, and I wished to make sure that
2069 certain features of that description were correct. I had no commercial interest in examining the file wrapper and did not examine it at the request of anyone else.

XQ25. And having so obtained access to the Mattullath application, you later disclosed your knowledge of it and of the fact that there was such an application to either Mr. Glenn H. Curtiss, one of these defendants, or Mr. Newell, counsel for defendants. Did you not?

A. I disclosed it to the whole world.

XQ26. I am not referring to a later time when your book was published, but to a time prior to its
2070 publication. Please now answer the question.

A. Prior to the publication I disclosed an account of Mr. Mattullath's investigations and patent application to many persons, for I regarded the application as abandoned and felt in no way obliged to secrecy.

XQ27. But you have not answered my question directly. Please do so.

A. I do not remember disclosing the fact of Mr. Mattullath's application to Mr. Curtiss, but I remember discussing with Mr. Newell, the first time

I met him in Washington, various devices for exerting a torque about the longitudinal axis of an aeroplane by changing the angle of incidence of the wings or ailerons, and in that conversation I may have told him about Mr. Mattullath's work and my connection with it, but I do not recall distinctly. This occurred when Mr. Newell was in Washington investigating the history of the three-torque system of control, and I met him accidentally in the library of the Smithsonian Institute. The exact date I cannot recall; it may have been in the year 1909. 2071

XQ28. And still you have not answered yet as to whether you disclosed to Mr. Newell the fact of this abandoned application being then in the Patent Office. 2072

A. I have answered as nearly as I can.

XQ29. Well, do you mean to say you do not know whether you disclosed to Mr. Newell the fact of such application being in the Patent Office, and that thereafter Mr. Newell applied to the Commissioner of Patents for a copy of such application as a result of your disclosure to him?

A. I cannot say positively, but I am certain that without looking at the file wrapper in the Patent Office I could have told him both of the existence of the patent application and of the general nature of it. My examination of the wrapper was not in the interest of Mr. Curtiss, and not prompted by Mr. Newell. 2073

XQ30. Well, I wish you would squarely answer this one question; did you disclose to Mr. Newell the fact that there was this abandoned Mattullath application in the Patent Office?

A. I cannot positively assert, nor positively deny, that question; as stated before I may have mentioned in my conversation with Mr. Newell, on the

2074 history of the three-torque system of control, an account of Mr. Mattullath's work, and I think it even natural that I should have mentioned it to him.

XQ31. I wish you would state the month and year when this disclosure was made by you to Mr. Newell?

A. I do not assert that I did make the disclosure.

XQ32. You have stated that it may have been in the year 1909 that you had this conversation. Do you not now know that shortly after this conversation you had with Mr. Newell, the latter ap-
2075 plied to the Commissioner of Patents for a copy of the Mattullath application?

A. I am aware that Mr. Newell secured a copy of the Mattullath application, but I do not know approximately the time.

XQ33. Do you mean to say that you do not now know that the time of your conversation with Mr. Newell was before his application to the Commissioner for a copy of the Mattullath papers?

A. I cannot say positively, but as I first met Mr. Newell when he was investigating the prior art, I can well believe that he applied for a copy of the Mattullath application after our first conversation,
2076 and in our first conversation I think it quite natural that I should have told him about my acquaintance with Mr. Mattullath's work.

XQ34. Do you not know that when you disclosed to Mr. Newell the fact of this Mattullath application, he indicated that such was the first knowledge on his part that there was such an application?

A. I cannot say positively whether he so indicated or not.

XQ35. Do you mean to say that it was not through you and your disclosures to Mr. Newell,

regarding the Mattullath application, that Mr. 2077
Newell took the step to obtain the copy of it?

A. As already indicated by my answers, I do not deny that I may have told Mr. Newell of the existence of Mr. Mattullath's application and the general nature of his invenion. The natural consequence of this might, of course, be that Mr. Newell would wish to examine the application for himself.

XQ36. Your answer is very diplomatic. You resort, to "might" and "may," but I ask you for a direct answer and would thank you to give it if you are willing to do so.

A. I do not deny that Mr. Newell's examination 2078
of the Mattullath application may have resulted from our conversation.

XQ37. As you seem to have been thrown with Mr. Mattullath more or less during 1901 and 1902, I will ask you if it is not the fact that for a number of years prior to his death Mr. Mattullath had lived apart from his family.

A. He lived most of the time in Washington and Pittsburgh for business reasons, but occasionally visited his family in New York, and on several occasions told me of his visits without indicating that there was any estrangement between himself
and his family. 2079

XQ38. During what years did he live in Washington and Pittsburgh?

A. He spent a part of the winter of 1900 in Washington while pressing his patent application. He travelled about during the Winter for some days consulting engineers regarding his project. Then, as I remember, he spent the Spring in Pittsburgh, also the Summer of 1900. I do not recall where he spent the Autumn, but I know he was in Pittsburgh in December, 1900, and returned to Washington that same month. He spent nearly all of 1901 and

2080 1902 in Washington, actually at work promoting his invention.

XQ39. From your then association with him, you can say that he thus lived apart from his family during 1901 and 1902, and also in 1899 and 1900, can you not?

A I can say that he lived apart from them without saying anything as to whether there existed an estrangement during those years.

XQ40. And can you state from your association with him, how early he began to live apart from the family?

A. I first met Mr. Mattullath in the Autumn of
2081 1899, when he came to Washington to consult me. From here he went to Cornell University and afterwards to Detroit, where he spent many days with his patent attorney. He thus apparently lived apart from his family in the Autumn of 1899, but I cannot go beyond that time.

XQ41. And during the period you have covered, as to his living apart from his family, he did not contribute to their support, did he, as you learned from him?

A. I do not recall his giving me any information on that question.

XQ42. But you so understood from him, did you
2082 not?

A. I cannot say that I did so understand.

XQ43. But you got that impression from what you know of his affairs, did you not?

A. I remember that he borrowed some money from me, saying that there was to be a wedding in the family, from which I inferred that he meant to use the money for his family in some way. On another occasion he told me of having borrowed money from his wife, and seemed very eager to return it promptly.

XQ44. You have stated that he died of apoplexy.

This leads me to ask you if he was a man of full or dissipated habits. 2083

A. He drank regularly, but I never saw him drink to excess. During our early acquaintance he drank beer occasionally, and during our entire acquaintance he used brandy regularly for sustenance; having Brights Disease he was unable to eat ordinary foods with a relish.

XQ45. My questions as to his living apart from his family, and as to his personal habits, are not intended to have any unkind aspect. I wish this to appear on the record. But I deem it a duty to obtain as good a picture of the manner of man he was as you are able and willing to give. I there- 2084
fore ask you another question. Do you know whether, at times, he so far indulged that he was more or less under the influence of liquor.

A. No, I should say otherwise. He used liquor purposely to strengthen and improve himself, according to his judgment, during the period of our acquaintance. When I first met him he told me that he did not expect to live many years owing to his fatal complaint, and therefore he husbanded his resources with the greatest care and always under the direction of a physician.

XQ46. Referring to your own patent application on the so-called equalizer, I will ask you this 2085
question: If, in fact, there is no turning of the aeroplane pictured in your application drawings, on a vertical axis due to unequal pressures on the ailerons when set to recover lateral balance, then there would be no object in having your alleged device. Is that correct?

A. Apparently there is no object in employing my device on a symmetrical aeroplane like the one shown in the drawing, but on a machine unsymmetrically loaded, as, for example, in a Wright machine, when an unusually heavy man occupies

2086 the outside seat so as to cause a continuous tilting torque on the machine, requiring the continuous use of the ailerons to maintain balance, there might be a continuous torque about the vertical axis. In this case the balanced ailerons would seem desirable. As previously stated, the symmetrical machine shown in the drawing was given to the draftsman for convenience and was thought to serve the purpose of a general application which would cover machines in which the balanced ailerons might be very important. Another idea in view was that as my computations had shown that, theoretically, there might be a minute spin about the vertical
2087 axis, if the Court should decide that this minute spin necessarily had to be counteracted by turning the vertical rudder towards the aileron having the least angle of incidence, and thereby infringing the patent in suit, the balanced ailerons would obviate even that minute theoretical turning.

XQ47. If, in Curtiss machines such as shown in your application drawing, a passenger, in addition to the aviator, sat at one side, as you have stated in your last answer with reference to a passenger in a Wright machine, would the Curtiss machine, in such case, tilt down on the side occupied by the passenger?

2088 A. Theoretically, the machine would tend to tilt toward the side having the greater weight in straight forward, even flight.

XQ48. In such case the machine would be what you have termed, unbalanced or unsymmetricai, would it?

A. It would be unsymmetrical in respect to the loading. There can also be unbalance in respect to the wind resistance offered.

XQ49. And in such case the greater resistance of drift would be on the lower side in the machine illustrated in your application drawing. Is that correct?

A. I could not reply positively without having 2089
all the conditions specified. Other things being equal, I should judge that placing a large man on one side of a machine which had previously flown in perfect balance with a small man, would increase the resistance on that side of the machine as well as tend to tilt it down.

XQ50. Are you still prosecuting before the Patent Office this application of yours relating to the so-called equalizer?

A. I have made no communication to the Patent Office regarding this application for a very long time, in the neighborhood of a year, I think. I
do not know whether my attorney has taken any 2090
action within the past year.

XQ51. You mean that the interference proceedings are still pending and in progress?

A. Substantially so.

XQ52. Has Mr. Curtiss taken the testimony in support of his application in this interference proceeding?

A. Not to my knowledge.

Redirect examination by Mr. Newell:

RDQ53. In XQ17 you were asked whether you wrote a letter to Mr. Behrens stating that you
did not know of Mr. Mattullath having any "pat- 2091
ents" on flying machines. Did you, or do you now know of any patent granted to him on any flying machine?

A. I did not and do not know of any.

RDQ54. How do you consider computations in flying machine questions compare in value with actual experiments carried out with the actual machines?

By Mr. Toulmin: Objected to as improper in the examination of Dr. Zahm.

A. In general, I place more confidence in a care-

2092 fully made experiment than in theoretical computations, particularly when the physical constants which form the basis of such computations are not perfectly reliable, and when the application of those constants involves other uncertainties.

RDQ55. Do you consider that, regarding calculations in flying machine problems, the art of flying machines is an exact science?

By Mr. Toulmin: Same objection repeated once for all.

A. It has not been up to the present.

RDQ56. Was Mr. Mattullath a painstaking in-
2093 vestigator, or was he willing to let things go without much investigation?

A. Where great precision was desirable, he was painstaking, but where approximate results would answer he experimented rapidly.

RDQ57. Was he a visionary dreamer, or a man who made investigations before taking a radical step in a matter?

A. He was methodical and careful in planning and carrying out important experimental work. He had studied at the University of Koenigsburg, in Germany; he was an educated man; he had had considerable business experience; he was familiar
2094 with the handling of men; he had previously managed a large factory employing many men handling machines, and had made many preliminary experiments with aeroplane models, so that he seemed well equipped by his previous training and experience for the undertaking he had in hand; and, moreover, from his theoretical discussion of his aeroplane with me and with scientific men in my presence, and from calculations made by him, I am convinced that he was not a dreamer but sufficiently qualified both in theory and in practice to develop a useful aeroplane.

By Mr. Toulmin: The answer is objected 2095
to for the obvious reason that it is a mere conclusion of the witness, and as much of it appears to be not from personal knowledge.

RDQ58. Did he keep on with the prosecution of his application in the Patent Office for a patent, up to the time he died?

A. That was his intention, and I remember hearing him say not long before his death that he had made an amendment, or sent in some communication to the Patent Office, for the express purpose of keeping the application alive.

RDQ59. In answering XQ49, did you intend that 2096
the word "resistance" therein should be a resistance exerted by the air upon the body of the man, or an unbalanced aileron torque resistance?

By Mr. Toulmin: Objected to as practically suggesting the desired answer.

A. I had in mind the resistance upon the body of the man.

ALBERT F. ZAHM.

Counsel for defendants herewith introduces a certified copy of the mandate of the Court of Appeals of the District of Columbia, to the Commissioner of Patents, in No. 2097
751 Patent Appeal Docket, April term 1912, in the matter of the Mattullath appeal, and requests that the same be marked as Defendants' Exhibit "Mattullath Mandate."

Certificate as to these two depositions of Capt. Beck and Dr. Zahm, just taken, is hereby waived, and it is agreed that the originals may be taken by Mr. Newell and sent to the Clerk of the Court for filing immediately.

Adjourned subject to further notice.

2098 **Notary's Certificate.**

District of Columbia, ss.:

I, Gertrude M. Stucker, a Notary Public in and for the District of Columbia, acting as a competent officer by consent of counsel, and as understood by the Commission of the Court, to take depositions in the above-entitled cause, hereby certify that I was attended, as therein stated, on the 27th and 29th days of April, 1912, at the offices of Messrs. Meyers, Cushman & Rea, McGill Building, Washington, District of Columbia, by Mr. H. A. Toulmin, counsel for complainant, and
2099 Mr. E. R. Newell, counsel for defendants, and by witnesses Captain Paul W. Beck and Dr. Albert F. Zahm; that the said witnesses were first duly sworn to testify the truth, the whole truth, and nothing but the truth, and examined at the times specified in the record hereby certified; that said depositions were read by the said witnesses before signing same; that they signed the same in my presence; that the exhibit mandate referred to in connection with the depositions of the witnesses aforesaid was duly offered and marked as indicated in the foregoing record; that I am not of counsel, nor connected by blood or mar-
2100 riage with either of said parties, nor interested directly or indirectly in the matter in controversy.

In testimony whereof, I have hereunto set my hand and official seal this 13th day of May, 1912.

GERTRUDE M. STUCKER,
Notary Public.

UNITED STATES DISTRICT COURT, 2101

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY,
Complainant,

vs.

THE HERRING-CURTISS COMPANY and GLENN H. CURTISS,
Defendants.

In Equity No. 400.

Pittsburgh, Pa., May 9th, 1912. 2102

Testimony taken for defendants in the above-entitled cause before Letitia A. Myers, Notary Public in and for the County of Allegheny, State of Pennsylvania, under the statutes, pursuant to telegraphic notice and agreement.

Present—H. A. TOULMIN, Esq., for Complainant.
E. R. NEWELL, Esq., for Defendants.

Thereupon, HERMANN LAUB, a witness produced in behalf of defendants and having been first duly sworn, deposes and says in answer to questions propounded by Mr. Newell, as follows, to wit: 2103

Q1. Please state your name, age, residence and occupation.

A. Hermann Laub, age 57; residence 3436 Bouquet Street, Pittsburgh, Pa.; occupation, consulting engineer.

Q2. Did you ever know Hugo Mattullath, and if so, please state about when you first knew him and when he died.

A. I met Mr. Mattullath either in the latter part of 1899 or in the early part of 1900, here in Pittsburgh and was acquainted with him until he died in December, 1902.

2104 Q3. Did you, during these years, know aything
about any flying machine invented by him?

A. Yes, I knew from the time he first met me. He came to my office for the purpose of my assisting him in his work.

Q4. Will you please describe the airship construction which he disclosed to you?

A. His airship consisted of three horizontal
planes from which boats were suspended by
vertical shafts. Propellers between the lower
planes were arranged and machinery by which
these propellers were driven was arranged in these
boats. Vertical rudders were arranged to give the
2105 air ship a side motion. At each side of the
planes, pivoted planes were arranged to hold the
air ship horizontal.

Q5. Please explain what the vertical rudder or rudders were for?

A. To change the direction of the airship.

By Mr. Toulmin: Objection is made once
for all to any statements of the alleged
invention made by the witness as purely
secondary since the Mattullath application
is the best evidence of what Mr. Mattul-
lath's proposals were and a copy of such
2106 application has already been introduced by
defendants.

Q6. Please explain what was the purpose of the small pivoted planes which you have said were located on each side of the machine.

A. They were arranged for the purpose to hold the airship in a horizontal position. If one side raised up, to bring it down by the action of these planes.

Q7. Were these pivoted planes at the side on horizontal pivots or otherwise?

A. On horizontal pivots.

Q8. Did you have anything to do with making any drawings of such a construction with Mr. Mattullath? 2107

A. Yes, I think I got some of his first patent drawings out which you showed me, but they are not in my office any more. I do not know where they are.

Q9. If you helped Mr. Mattullath in experiments with relation to this flying machine, please state what they were.

A. Mr. Mattullath built a shop in Washington, D. C., at the Catholic University where he made experiments as to skin friction by great speeds. He also made a model of the propeller to determine the efficiency and made various sections of the planes to 2108
find out the strength of said planes against heavy wind. I have been in Washington once or twice during the time he was there—I suppose for a year and a half—and saw things work, as he was principally assisted by Prof. Zahm.

Q10. You have spoken of a propeller or propellers. Will you please state whether they rotated in a vertical plane or otherwise and what their construction was.

A. These propellors rotated in a horizontal plane around a vertical axis and a number of blades or planes were placed which raised vertically, say in 2109
the direction of the boat going and then flattened down when they came in the rear, and so on.

Q11. When the blades of the propeller raised up to a vertical position, what did they then do?

A. They would then strike against the air.

Q12. Did Mr. Mattullath, so far as you know, build a complete full-sized airship during his lifetime?

A. No.

Q13. Did he give any reason why he did not do so. If so, what was it?

2110 A. He said he would not build toys. He often was asked by investors to build an airship on a small scale but he objected to it. He said he would try out all the details first and build the airship on a large scale after he was satisfied with all the details.

Q14. Did you know Jacob Schineller?

A. Yes, sir.

Q15. Is he alive?

A. No, he is dead for the last three or four years.

Q16. Do you know whether Mr. Mattullath also disclosed this construction of airship to Mr.
2111 Schineller?

A. He did so.

Q17. What was Mr. Schineller's occupation?

A. Mechanical engineer.

Q18. Was he also consulted by Mr. Mattullath?

A. Yes, sir. Especially as to the mechanical part of his airship.

Q19. I show you here Defendants' Exhibit, Mattullath Application, and ask you how the drawings thereof compare with the construction of airship which Mr. Mattullath disclosed to you and Mr. Schineller?

A. These drawings are the same as he intended
2112 to build his airship and which he showed to us.

Direct Examination Closed.

By Mr. Toulmin: Without waiving the objections given, the cross examination is proceeded with.

Cross examination by Mr. Toulmin:

XQ20. Before you began to testify, you had been shown this drawing of the Mattullath application?

A. Yes, sir. 2113

XQ21. You examined it this morning just before you began to testify, did you not?

A. No, I saw them before.

XQ22. When for the last time?

A. About ten days ago.

XQ23. Have you talked with anyone lately with reference to the purpose of the side planes shown in these Mattullath drawings?

A. With nobody.

XQ24. Have you talked with anyone lately about the so-called vertical rudder shown in these application drawings?

A. No, sir. 2114

XQ25. Who submitted to you a copy of this Mattullath application with these drawings?

A. Mr. Newell.

XQ26. Did you talk with Mr. Newell about these drawings?

A. Just a few minutes before we commenced.

XQ27. About what size was this horizontal propeller which Mr. Mattullath made in Washington?

A. The round propeller? I should say about $3\frac{1}{2}$ to 4 feet in diameter. This was the size of the model that we experimented with.

QX28. At whose expense was Mr. Mattullath's laboratory erected? 2115

A. At the expense of Pittsburgh investors, Mr. Grimes, Mr. Frank Moore, Mr. Charles H. McKee.

XQ29. You say that the investors wanted Mr. Mattullath to go forward and build a machine on a small scale but that Mr. Mattullath objected?

A. Yes, he objected to it. I think he was perfectly right, as experience shows now.

XQ30. You mean experience shows that models cannot be relied upon?

A. That we have a great many failures with these small aeroplane models.

2116 XQ31. Have you any idea how much money Mr. Mattullath expended?

A. Only from hearsay; about twenty thousand dollars.

XQ32. Did you receive a letter in 1903 from Mr. Behrens, the son-in-law of Mrs. Mattullath asking you whether Mr. Mattullath, when he died, had left any patents on flying machines or anything of value concerning flying machines?

A. No, sir, at least I cannot remember.

XQ33. Do you know whether any of the other gentlemen who had been associated with Mr. Mattullath received such letter from Mr. Behrens?

2117 A. I do not.

XQ34. You understood that Mr. Mattullath lived apart from his family during the time you knew him?

A. He never mentioned that to me, but I heard so.

XQ35. And did you also learn from your association with him and his associates that he left the support of his family to someone else than himself?

A. I did not.

XQ36. Why was it that Mr. Mattullath seems to have consulted with so many engineers, for in-
2118 stance, yourself, and Mr. Schineller and Prof. Zahm?

A. And I expect with a good many more for the purpose of getting money for making his experiments and finally to complete the airship.

XQ37. Did he not consult with engineers to get information and assistance?

A. Possibly to a certain extent, but he was rather a strong minded man and I assisted him principally in the building of the planes. He wanted to have a light, strong plane and since he was not quite so

theoretical as we engineers, he needed some assist- 2119
ance in getting at some facts.

XQ38. You say you assisted him in building these planes? You mean you advised him as to how to build them for strength?

A. He would make the suggestions as to how he would build it. He was quite a practical man. Afterwards I figured as an engineer more to see how it would stand or resist.

Cross Examination Closed.

Redirect examination by Mr. Newell:

RDQ39. You spoke of the record here a few 2120
minutes ago of some planes which Mr. Mattullath built. Please state what these were and what they were for.

A. These planes consisted of wooden boards about—I will speak of the model—about six inches apart, braced by wooden beams and wire so as to make them very strong when in action.

RDQ40. Were these used in the experiments in the wind tunnel at Washington?

A. No. It was simply to establish the strength of these planes.

RDQ41. When you and I talked over this matter 2121
this morning before Mr. Toulmin came in, did I talk the matter over with you first or did I first show you the application which is lying on the table there?

A. I think we talked first in a general way and then you asked me if I ever saw this application.

RDQ42. Several days ago I wrote you and sent you a copy of Figures 1 and 2, did I not?

A. Yes, sir.

RDQ43. And asked you if you knew anything about this Mattullath matter?

A. Yes, sir.

2122 RDQ44. What did you reply to me?

A. I answered your letter saying that I was familiar with these drawings and the application for this patent.

RDQ45. When did you first meet me?

A. This morning at 9:30.

Deposition Closed.

Signature Waived.

And thereupon JAMES F. GRIMES, a witness introduced in behalf of the defendants, and having first been duly sworn, deposes and says in answer
2123 to questions propounded by Mr. Newell, as follows, to wit:

Q1. What is your name, age, residence and occupation?

By Mr. Toulmin: There was no notice served of this witness but there is no objection made on this account.

By Mr. Newell: I never met Mr. Grimes until this morning and had no communication with him and did not know until I got here this morning whether he knew about the matter or not.

2124

A. James F. Grimes, age 66, residence Knoxville Borough, Pittsburgh, Pa.; real estate.

Q2. Did you ever know Hugo Mattullath, and if so, please state how long you knew him.

A. I first met Mr. Mattullath in the Winter of 1899-1900. I was introduced to him by Mr. Schineller at Mr. Schineller's office. I knew him until he died.

Q3. Were you one of the men who furnished Mr. Mattullath with money to conduct his experiments in regard to his airship?

A. I gave Mr. Mattullath one thousand dollars in order that he could go to Washington and make applications for patents. That I gave myself of my own volition. Nobody else was associated with me at that time. Mr. Laub and Mr. Schineller had informed me that they had gone over his plans and that he had a very good proposition and I gave him one thousand dollars to go to Washington. He at that time assigned me one-tenth interest in his patent. 2125

Q4. You were here in the room while Mr. Laub has been testifying. Please state whether or not the machine which Mr. Laub testified to was the one which Mr. Mattullath was then working on. 2126

A. Yes, sir; it was.

Q5. This machine was known to you; that is, by description?

A. Yes.

Q6. If Mr. Mattullath ever gave any reason why he did not build a full sized machine, please state what that reason was.

By Mr. Toulmin. Objected to as immaterial.

A. That was what we were working to when he died, the building of a machine. Before starting to build the machine that he had planned, he first, against my wishes, experimented with every detail and part of the construction of the machine before he would attempt to build the machine, and at the time of his death he had reached the conclusion of his demonstrations and experiments and we were getting ready to go on with the practical construction of the machine. 2127

Q7. Do you know of Mr. Mattullath's having consulted with Mr. Laub and Mr. Schineller?

A. Oh, yes.

Direct Examination Closed.

2128 By Mr. Toulmin: Without waiving the objection of record, the witness is cross examined.

XQ8. Have you lately seen a copy of the Mattullath application and drawings?

A. No, sir, except as it is lying on this table here. Well, I did see yesterday, in Mr. Laub's office for a moment, those two drawings that Mr. Newell sent him.

XQ9. When you invested your thousand dollars, you knew nothing of the problem of aeronautics, did you?

A. Nothing more than what I had learned from
2129 consultation with Mr. Laub, Mr. Mattullath and
Mr. Schineller. I am not a technical engineer, and I saw his sketches and plans which he had, discussed with him, but I am not an expert on those sort of things and I based my investment upon the opinions and judgment of Messrs. Schineller and Laub together with letters from Prof. Cooley and other eminent men in the country whom Mr. Mattullath had consulted and to whom he had submitted his plans for aerial navigation.

XQ10. Did you visit the laboratory in Washington where Mr. Mattullath conducted his experi-
2130 ments in skin friction, etc., as stated by Mr.
Laub?

A. Yes, sir; at different times.

XQ11. The things which you saw were the things which Mr. Laub has testified to?

A. Yes, sir.

XQ12. How many financial men were interested in the project?

A. Afterwards Mr. McKee and Mr. Moore were the only men interested in the matter financially.

XQ13. Did not dissatisfaction arise on the part of the moneyed men that Mr. Mattullath expended the money in the laboratory and in making the things which Mr. Laub has spoken of?

A. No, I never heard an expression of dissatisfaction. We accepted it as part of the necessary experiments and went along with his ideas that he would demonstrate everything before he would build the airship. 2131

XQ14. Was Mr. Mattullath paid a salary during that time for his services and expenses?

A. We provided a salary which he received.

XQ15. And that continued until his death?

A. Yes.

XQ16. And during these years he lived apart from his family?

A. I do not know that. I never met any part of his family. I only know that at different times 2132 he came to me and said he would have to have some money to send to his wife. That is all I ever knew about his family connections.

Cross Examination Closed.

Redirect examination by Mr. Newell:

RDQ17. Who was the Prof. Cooley which you mention?

A. He was of Ann Arbor, Michigan, of the University of Michigan—a very eminent man in the country in scientific lines. 2133

RDQ18. Mr. Mattullath consulted Prof. Cooley in an advisory capacity in regard to his proposed machine?

A. I think so. I was not present. I have copies of the letters that I made that he had received from different eminent men and he wanted a large sum of money to build the vessel with and I told him I would get it from the public if he would get me from the eminent men of the country endorsements of his plans. He had, before I told him this, shown me letters from Prof. Chanute and Prof. Durand. He seemed to

2134 want to have the support of the best minds in the country for his plans as he worked them out.

Deposition Closed.

Signature Waived.

By Mr. Toulmin: All the testimony of these two witnesses is objected to on the ground that it is wholly immaterial since it shows but a speculation without any successful end.

By Mr. Newell: It is hereby stipulated
2135 that the following letter—all written in ink—has just been produced by Mr. Grimes, who stated that it was from Mr. Mattullath and that he knew Mr. Mattullath's writing and that it was signed by Mr. Mattullath and was received by him through the mail from Mr. Mattullath on or about the date given in the letter. The letter is as follows:

"(Letter Head)

THE RALEIGH
European Plan
Absolutely Fireproof
2136 T. J. Talty, Manager.

Washington, D. C. Feb. 24th, 1900.

My dear Mr. Grimes:

On Tuesday I moved against the Examiner (Townsend) after using my letter from Cooley. I found that the Patent Office does not issue patents on Air Ships without balloon. They have not done so for five years and it is said that 200 applications are pending.

They deny the usefulness as heretofore

nothing has been operative. In some respects that is good, for it assures me of my claims not being anticipated, and any ideas coupled with inoperative machines don't count. 2137

Well Townsend told me the first thing that he would not reach the application for 10 days yet. That he could not take it up outside of its turn except by order of the Commissioner, that such order was never given except on request of the head of one of the departments. He would not study the art with me, for it would be useless. He would simply call for a working model 2138
that would prove the invention useful and that always ended it. They had not received such model and did not expect it.

They could and would not change that practice. I told him that I approved of it as it protected me, but that I wanted the application thoroughly examined, as it was strongly endorsed by science and should not be treated as a crank's product. That I did not want Patents to issue now, indeed much rather would take them later, but that I wanted the claims allowed to which I was entitled, for I did not want to build a vessel 2139
and afterwards be told that other people were entitled to the claims on my invention.

I then gave him a lecture on the invention, about which he did not say much but listened for two hours.

I left him feeling that I had a hard fight before me.

I then saw Prof. Zahm and we consulted Doolittle, who corroborated what Townsend had said. He thought that pressure would only hurt, but finally agreed that it might

2140 do some good if I got well introduced to the Commissioner and tried to interest him from a scientific standpoint.

Doolittle was very clear headed on the question. Then I saw Andrews who promised that Penrose would give me a very good introduction.

Next I sent Zahm to Townsend under pretext that he wanted to find out something in regard to an English Patent on a soaring machine. I thought that Zahm might succeed in drawing information how hostile Townsend would act. Now imagine my as-
2141 tonishment.

Townsend had taken up the study of my application immediately and evidently very diligently. He was glad to see Zahm to whom I had referred. Mr. Townsend spoke about as follows. We are overrun with cranks, who are all very confident and give us much trouble. We are afraid of them, but if this man is a crank, he is certainly the most intelligent and sensible I ever came across. His invention has certainly great merits and his claims are novel and essential.

2142 The catamaran shape and the operating on the water is a great idea, and novel. He even intimated that I might claim more. Then he got Zahm to explain different things and thanked him heartily.

In short, Zahm thinks that we have an enthusiastic friend in Examiner Townsend. Zahm promised to meet him again.

Townsend is warmed up and we will make him pretty hot. When I then meet the Commissioner and he talks with him, we will get the whole Patent Office well stirred up.

which will be a great triumph after they 2143
have been treating the subject for five years with contempt.

I think I can manage to get an expression of that feeling in contrast with other efforts and it will go farther maybe than the endorsement of science with many men.

I will go to Cornell and Harvard anyhow, probably on Wednesday.

My address is this Hotel. I thought it prudent. Zahm is writing the letter for McKee and we may get through Monday. He is also making a model of the propellor.

Zahm is a positive believer in our success 2144
and spends every hour of his spare time with me.

He is very well connected socially and I could not have got a better assistant. He is absolutely disinterested and nothing but the glory attracts him apparently.

This week commenced badly and ended well. I think we may not need borrow trouble from the final outcome of the undertaking for even at this stage it seems irresistible and conquering even official prejudices.

Write occasionally to 2145

Yours sincerely,

H. Mattullath."

By Mr. Toulmin: But the stipulated waiver of the recall of Mr. Grimes for proving the above letter is not a waiver of my objection to the letter. I object to it as incompetent on the ground that I have not had an opportunity to cross examine the alleged author of the letter. Also on the ground that it is an *ex parte* statement made

2146 by a now deceased person concerning a matter in which complainant had no interest for which reason they cannot be bound or their rights affected by the letter.

Thereupon CHARLES H. McKEE, a witness introduced on behalf of the defendants, being first duly sworn, deposes and says in answer to questions propounded by Mr. Newell, as follows, to wit:

Q1. Please state your name, age, residence and occupation.

A. Charles H. McKee, age 58; residence; Pitts-
2147 burgh, Pa.; attorney at law.

Q2. You are the senior member of the firm of McKee, Mitchell & Alter in the Park Building, City of Pittsburg?

A. Yes.

Q3. If you ever knew Hugo Mattullath during his lifetime, please state about how long you knew him.

A. I knew him for two or three years, perhaps more.

Q4. If he ever disclosed to you his proposed flying machine, will you please give a general description of what the construction was?

2148 A. He disclosed to me various plans he had with respect to flying machines and to one in particular, that he arranged to build. It, as I recall it, consisted of large horizontal planes arranged one above the other, with stanchions between to support them. He, as I recall it, contemplated a vessel some 200 feet in length to start with, perhaps 40 or 50 feet in width, and he arranged to drive it with motors revolving fans, which were to be set on each side of the vessel. They were to rotate horizontally and blades arranged so that each blade was exposed during its movement to the rear and

then it feathered and came inside of a house or 2149
"cheese box" as we called it. His plan for steering consisted in planes arranged on each side of the vessel pivoted horizontally so that he could change the angle of these horizontal planes to raise and lower the vessel and in other respects the vessel was to be steered by planes at the end. I am not sure as to planes at both ends but as I recall the matter, he had one or more vertical planes at the rear end by which he could change the course horizontally.

Q5. What was the provision for righting the machine if one side of the machine tilted out of the horizontal? 2150

By Mr. Toulmin: Objected to as leading and suggestive.

A. This was accomplished by means of the steering planes, that is, the horizontal pivoted planes.

Q7. I show you here, Defendant's Exhibit, Mattullath Application, and call your attention to the drawings and ask you how these drawings compare with the construction which Mr. Mattullath disclosed to you.

A. Oh, these are the same. In fact, I have some place in this office, copies of these same drawings.

Q8. Do you know James F. Grimes and Herman 2151
Laub and also do you know Jacob Schineller?

A. Yes, sir.

XQ9. Please state whether or not all these men were in consultation with Mr. Mattullath during his lifetime with relation to his proposed flying machine?

A. They were. I met Mr. Mattullath in company with all of these gentlemen at different times although I do not recall that I ever met him in company with all of them at the same time.

Direct Examination closed.

2152 Cross examination by Mr. Toulmin:

By Mr. Toulmin: I object to the entire deposition as immaterial and incompetent because it relates to a mere speculation which came to no end but failure. Without waiving such objections, the witness is cross examined.

XQ10. The Mr. Grimes you have spoken of has stated to me that he put a cost of from $200,000 to $300,000 to have built one of these proposed Mattullath machines. Do you think that is a correct statement?

2153 A. No, sir. I am rather surprised at that, knowing as much as I do of what was proposed by Mr. Mattullath.

XQ11. You have said that the proposed vessel was to be some 200 feet long. And this application before you states that the horizontal propellers were to be about 40 ft. in diameter. The drawings show two of these abreast and three in tandem. Was not the proposed machine therefore to be exceedingly large?

A. Mr. Mattullath had in mind that a practical machine on his plan should be quite large although they might be of different sizes. He favored a ma-
2154 chine several hundred feet in length and did not think it extraordinary to speak of a machine a thousand feet in length for heavy duty. He always disparaged the idea of using small machines and had a favorite illustration which consisted in referring to what a vessel would do in the way of crossing the whirlpool below Niagara Falls. He pointed out how a light vessel might not live in the whirlpool whereas a large one might cross over in safety and he contended that in the air, the vessel should be large in order to contend with the air currents.

XQ12. Did you invest in this enterprise?

A. I invested with others to carry on some research work and some experimental tests. Among other things, we put in the money which was expended in constructing his first propeller. 2155

XQ13. You mean a model of his proposed propeller?

A. No, I mean a propeller which was of quite considerable size and reached good practical limits in which the very high speeds of the blades were developed and tested out. It had a circular track which, I should say, was eight feet in diameter. It was driven by an electric motor.

XQ14. That is, it rested on supports which were on the ground or floor and then the motor was 2156 applied to turn this propeller in a horizontal plane?

A. Yes.

XQ15. Mr. Laub, the engineer, stated in his testimony this morning that this was a model propeller about three feet in diameter. Do you agree with him or differ?

A. I differ with him, although I realize my memory may be at fault.

XQ16. Did you lose the money you put in?

A. In a sense, no. It stayed where it is. It is not lost.

XQ17. Well, where is it? 2157

A. It was expended largely for labor and materials and for Mr. Mattullath's maintenance for the course of I should say, about two years.

XQ18. Then this money was spent but no returns were ever had. Is that correct?

A. No returns, in the way of money, but it does not follow that we had no returns.

XQ19. Well, what returns did you get?

A. Through the research work we gained much information which, had Mr. Mattullath lived, would likely have been applied to usefulness in

2158 connection with this art. I do not think we have any right to regard any of the money as squandered or lost. His experiments with regard to skin friction alone resulted in gaining accurate and desirable information and his tests with respect to what might be accomplished by propellers was also in the way of gaining accurate information that might be applied in this art.

XQ20. About how much money was expended altogether?

A. I have the impression that there was expended somewhere in the neighborhood of fifteen thousand dollars.

2159

Deposition Closed.

Signature Waived.

It is hereby stipulated by and between counsel for the respective parties that if Prof. Cooley, mentioned by Mr. Grimes and in the letter of Mr. Mattullath were called, he would testify that he is a professor in the Department of Mechanical Engineering at the University of Michigan, at Ann Arbor, Mich.; is 56 years of age; that he knew Hugo Mattullath during said Mattullath's lifetime; was consulted by said Mattullath with
2160 relation to Mattullath's proposed airship, and that said Mattullath disclosed to him the construction of his proposed flying machine, which is set forth in the Defendants' Exhibit, "Mattullath Application."

In consideration of said stipulation, counsel for defendants further stipulates to eliminate the 14th and 15th of May, 1912, from the time now set by the Court in which he is to close his surrebuttal testimony.

It is also stipulated that as this testimony has been taken stenographically, it may be written out by the Notary and one copy sent to Mr. Toulmin and the original and other copies sent to Mr. Newell to be filed. 2161

Adjourned to meet subject to notice or agreement of counsel.

State of Pennsylvania, }
County of Allegheny, } ss.:

I, Letitia A. Myers, a Notary Public in and for the State and County aforesaid, do hereby certify that the foregoing depositions of Hermann Laub,
James F. Grimes and Charles H. McKee, were 2162
taken by me as Special Examiner by agreement of counsel, pursuant to notice; that said depositions were taken in behalf of the defendants in the suit of The Wright Company *v.* The Herring-Curtiss Company and Glenn H. Curtiss, pending in the United States District Court, for the Western District of New York; that there were present at the taking of said depositions, H. A. Toulmin, Esq., for complainant, and E. R. Newell, Esq., for defendants, and the witnesses named; that the witnesses were sworn by me before said depositions were taken, that all of said witnesses did
and do live outside the Western District of New 2163
York and more than 100 miles from the place at which this cause is appointed to be tried; that said depositions were taken stenographically by myself in the presence of the above parties and transcribed by myself; that the foregoing is a full and correct record of the proceedings and depositions taken, the objections made and stipulations entered into by and between the parties; and I further certify that I am not an attorney, solicitor or of counsel for either of the parties, nor am I interested in the result of the suit.

2164 In witness whereof I have hereunto set my hand and affixed my seal this 10th day of May, A. D. 1912.

Letitia A. Myers,
[Seal.] Notary Public.

My commission expires May 17, 1915.

Defendants' Exhibit "Letter to Aero Club."

To the Aero Club of America—

Though America—through the labors of Professor Langley, Mr. Chanute, and others, had ac-
2165 quired not less than ten years ago the recognized leadership in that branch of aeronautics which pertains to bird-like flight, it has not heretofore been possible for American workers to present a summary of each year's experiments to a society of their own country devoted exclusively to the promotion of aeronautical studies and sports. It is with great pleasure, therefore, that we now find ourselves able to make a report to such a society.

Previous to the year 1905, we had experimented at Kitty Hawk, North Carolina, with man-carrying gliding machines in the years 1900, 1901, 1902 and 1903; and with a man-carrying motor-flyer,
2166 which, on the 17th day of December, 1903, sustained itself in the air for fifty seconds, during which time it advanced against a twenty-mile wind a distance of 852 feet. Flights to the number of more than one hundred had also been made at Dayton, Ohio, in 1904, with a second motor-flyer. Of these flights, a complete circle, made for the first time on the 20th of September, and two flights of three miles each, made on the 9th of November and the 1st of December, respectively, were the more notable performances.

The object of the 1905 experiments was to determine the cause of, and discover remedies for,

several obscure and somewhat rare difficulties 2167
which had been encountered in some of the 1904 flights, and which it was necessary to overcome before it would be safe to employ flyers for practical purposes. The experiments were made in a swampy meadow about eight miles east of Dayton, Ohio, and continued from June till the early days of October, when the impossibility of longer maintaining privacy necessitated their discontinuance.

Owing to frequent experimental changes in the machine, and the resulting differences in its management, the earlier flights were short; but towards the middle of September, means of correcting the obscure troubles were found, and the flyer was at 2168
last brought under satisfactory control. From this time forward, almost every flight established a new record. In the following schedule, the duration, distance, and cause of stopping are given for some of the later flights:

Date.	Distance.	Time.	Cause of Stopping.	
Sept. 25	17,961 meters (11½ miles)	18 min. 9 sec.	Exhaustion of fuel	
Sept. 29	19,570 meters (12 miles)	19 " 55 "	" "	
Sept. 30		17 " 15 "	Hot bearing	
Oct. 3	24,535 meters (15¼ miles)	25 " 5 "	Hot bearing	
Oct. 4	33,456 meters (20¾ miles)	33 " 17 "	Hot bearing	2169
Oct. 5	38,556 meters (24 1/5 miles)	38 " 3 "	Exhaustion of fuel	

It will be seen that an average speed of a little more than 38 miles an hour was maintained in the last flight. All of the flights were made over a circular course of about three-fourths of a mile to the lap, which reduced the speed somewhat. The machine increased its velocity on the straight parts of the course, and slowed down on the curves. It is believed that in straight flight the normal speed is more than forty miles an hour. In the earlier of the flights named above, less than six pounds of

2170 gasoline was carried. In the later ones a tank was fitted large enough to hold fuel for an hour, but by oversight it was not completely filled before the flight of October 5th.

In the past three years a total of 160 flights have been made with our motor-driven flyers, and a total distance of almost exactly 160 miles covered, an average of a mile to each flight; but until the machine had received its final improvements, the flights were mostly short, as is evidenced by the fact that the flight of October 5th was longer than the 105 flights of the year 1904 together.

The lengths of the flights were measured by a
2171 Richard anemometer, which was attached to the machine. The records were found to agree closely with the distances measured over the ground when the flights were made in calm air over a straight course; but when the flights were made in circles, a close comparison was impossible, because it was not practicable to trace the course over the ground accurately. In the flight of October 5th, a total of 29.7 circuits of the field was made. The times were taken with stop-watches. In operating the machine it has been our custom for many years to alternate in making flights, and such care has been observed that neither of us has suffered any
2172 serious injury, though in the earlier flights our ignorance and the inadequacy of the means of control made the work exceedingly dangerous.

The 1905 flyer had a total weight of about 925 pounds, including the operator, and was of such substantial construction as to be able to make landings at high speed without being strained or broken. From the beginning, the prime object was to devise a machine of practical utility, rather than a useless and extravagant toy. For this reason, extreme lightness of construction has always been resolutely rejected. On the other hand, every effort has been made to increase the scientific efficiency

of the wings and screws in order that even heavily 2173
built machines may be carried with a moderate expenditure of power. The favorable results which have been obtained have been due to improvements in flying qualities resulting from more scientific design, and to improved methods of balancing and steering. The motor and machinery possess no extraordinary qualities. The best dividends in the labor invested have invariably come from seeking more knowledge rather than more power.

(Signed) Wilbur Wright.
Orville Wright.

"Defendants' Exhibit Extract from Wright Affidavit in this Case." 2174

UNITED STATES CIRCUIT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY

v.

THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.

In Equity No. 400.

I, Harris S. Williams, Clerk of the United States 2175
Circuit Court for the Western District of New York, hereby certify that in an affidavit signed by Wilbur Wright and Orville Wright and sworn to on the 27th day of November, 1909, filed in this cause on November 29, 1909, prior to the hearing of the motion for preliminary injunction, the following extracts appear:

> "Complainants in the course of their experiments finally devised a machine having the combination of adjustable wings, adjustable at the will of the operator, and adjust-

2176 able vertical and horizontal rudders, the lateral balance being effected by the united action of the adjustable wings and adjustable vertical tail." * * *

"The complainants' experimental machines of 1900 and 1901 possessed wing tips adjustable in opposite directions to different angles of incidence. But it had no vertical or horizontal rear rudders, complainants believing that the adjustment of the wing tips alone would provide lateral control. But experiment proved that this was a mistake. The wing with the greater angle would not
2177 mantain its elevation, because, as we finally discovered, its greater horizontal resistance caused that wing to lag more and more behind the other wing; and since the lifting power is dependent upon speed as well as angle the effect of the reduced speed balanced the lifting effect of the greater angle, and the wing with the greater angle failed to rise. We thus failed to attain the result we wished. After much study of the phenomenon, we discovered the theoretical cause and remedied the trouble by inventing the machine of the patent in which the difference in
2178 horizontal resistance is corrected by an adjustable vertical rudder, while the difference in lifting effect is utilized in controlling the lateral balance of the machine." * * *

"The claim of Mr. Herring (Affidavit, page 1), that complainants' machine of the patent was capable of being directed in a straight line only is not well founded. We have repeatedly made complete circles with the rear rudder permanently connected with the wires which warp the planes as described in the particular form shown in the patent. Circles were usually made in a direction opposite to that which should have been taken if the rudder had possessed the functions of an ordinary ship's rudder. We turned to the left with the rudder straight or even set over slightly to the right." * * * 2179

"At p. 25 of said affidavit, it is stated that the machine of the patent could not be steered to the right or left by the rear rudder, and, in order to so steer, another and independently movable rudder would have to be added, making two rudders in all, one to counteract the turning tendency and the other to steer the machine. It is true that the machine was not turned to right or left by using the rear rudder as a boat's rudder 2180
is used, but by warping the wings the whole machine could be given a lateral inclination and caused to slide off to right or left according as the right or left wing was lower than the other. In circling it was necessary to set the inner wing to a larger angle of incidence than the outside wing, because it moved in a smaller circle than the outside wing and of course had less speed. The inside wing therefore had a greater resistance than the outside wing and tended to fall behind and the machine swung round the circle 2181
with the rear rudder set over toward the outside wing and receiving a pressure on the side toward the outside wing, a condition exactly opposite from what would have existed if the rudder had been a mere steering device."

The affidavit is signed

"WILBUR WRIGHT.
ORVILLE WRIGHT.

Subscribed and sworn to before me this 27th day of November, 1909.

Jonathan T. Holmes,
Notary Public,
(Seal) New York County."

2182 Witness my hand and the seal of this Court this 3rd day of November, 1911.

HARRIS S. WILLIAMS,

(Seal) Clerk.

Defendants' Exhibit Portion Paulhan Record.

UNITED STATES CIRCUIT COURT,

SOUTHERN DISTRICT OF NEW YORK.

I, THOMAS ALEXANDER, Clerk of the United States District Court for the Southern District of New York, hereby certify that in the suit of the
2183 Wright Company against Louis Paulhan pending in this Court, Paragraph 5 of the bill of complaint reads as follows:

"(5) Your orator further says that the defendant, well knowing the premises and rights secured to your orator as aforesaid, but contriving to injure your orator and deprive it of the just benefits, emoluments and rewards, which might and otherwise would have accrued to it from said letters patent and the invention covered thereby, did, prior to the commencement of this suit and subsequent to the date of said letters
2184 patent and to said assignment, against the will of your orator, and in violation of your orator's rights, and infringement of said letters patent, unlawfully, wrongfully and willfully import and bring into the United States, and this judicial district in particular, from one or more foreign countries, the Republic of France in particular, one or more certain flying machines embodying and containing the invention covered in and by your orator's said Letters Patent 821,393 and is preparing and threatening to import other similar machines; that defendant is preparing and threatening and announcing

his intention to make public flights or ex- 2185
hibitions of the same through the United States at which defendant (and his confederates now unknown by name to your orator) will, and is preparing to charge admission fees to the general public and is receiving or about to receive, large sums of gate or ticket money, all to the irreparable loss and injury of your orator, thereby depriving your orator of large sums of profits which it otherwise would make were it not for these unlawful acts of the defendant; and particularly that said defendant has so
imported from France into the Port of New 2186
York two certain flying machines, one a monoplane and the other a biplane machine, which he is about to remove from the United States Custom House, of this Port, and to ship to Los Angeles in the State of California, where he has arranged with certain persons (whose names are not now certainly known to your orator) to use said machines in making public exhibition flights before large concourses of people, all or most of whom are to pay gate or admission charges for the privilege of seeing said de-
fendant fly with one or both said infringing 2187
imported machines; and that said defendant is to receive as compensation for this and other uses of said infringing machines and his services in performing such exhibition flights therewith very large sums of money, something like one hundred thousand ($100,000) dollars as your orator is informed, understands and believes, and, therefore avers; that the confederating parties aforesaid who have so arranged with defendants are also through his aid and cooperation to receive large sums of gate and

2188 other moneys by use of said infringing machines; that said defendant is to receive said compensation, or so much thereof as has not already been advanced to him by said confederating parties, in such form as to be readily conveyed beyond the borders of the United States and on information and belief your orator avers he will leave this country and put the proceeds of his now intended and threatened infringement beyond the reach of complainant and of any ultimate process of this Court; wherefore your orator shows impending irreparable loss and hence
2189 prays for this special relief in addition to the usual relief herein prayed, namely, that this Court grant a temporary restraining order instanter preventing the removal of said imported infringing machines from the United States Custom House of this Port, or from this jurisdiction pending the hearing of a motion for a preliminary injunction to restrain defendant from removing from this jurisdiction and from using said machines until this cause be determined on final hearing, or for a bond in a sum sufficient to protect complainant from the losses
2190 consequent upon said public exhibitions of said machines by defendant; and for such other special relief as the equities of the case may require."

The Bill of Complaint is signed "THE WRIGHT COMPANY by Wilbur Wright, President," and the oath to the bill of complaint read as follows:

"State of Ohio, County of Montgomery, ss.:

On this 24th day of December, 1909, before me personally appeared Wilbur Wright, who being duly sworn deposes and says that he is President of the Complainant

Company mentioned in the foregoing Bill of Complaint; that he has read the said Bill and knows the contents thereof and that the same is true to his knowledge and belief except in so far as matters are stated on information and belief and as to those matters he verily believes them to be true. 2191

JOHN E. BARNES,
Notary Public,
Montgomery County,
(Notarial Seal) Ohio."

I further certify that in an affidavit filed in said cause on February 18, 1910, appears the following extract: 2192

"I am also very familiar with the Wright Patent, 821,393, and I testify to the Court that I have compared said patent with said Farman and Bleriot flying machines now about to be used by the defendant, and that I find in said machines structures which respond to the structures set forth and claimed in said patent, and particularly in claims 7, 14 and 15, and that the mode of operation of defendant's machines and the results obtained thereby are the same as set
forth and embodied in the said patent, and 2193
that the mechanism of defendant's machines is substantially the same as that also set forth and described in said patent."

The affidavit is signed

"WILBUR WRIGHT.

Subscribed and sworn to before me, a Notary Public, in and for Clark County, Ohio, this 6th day of January, 1910.

A. C. Link,
[Seal.] Notary Public,
Clark County, Ohio."

2194 In an affidavit filed February 18, 1910, and signed "L. PAULHAN," the following appears:

> "I call attention to the reckless averments in complainant's papers. I did not reach this country until the 3rd of January, 1910, and my machines did not arrive until the 27th of December, 1909. Yet Wilbur Wright swears of his own knowledge on December 24, 1909, that I brought into this country machines infringing the Wrights' patent. Furthermore, said machines, without being unpacked or set up, were transferred from the dock to the
> 2195 Wells Fargo Express Company and shipped West on January 2, 1910. Yet Wilbur Wright makes affidavit in Ohio on January 6, 1910, that he has compared the Wright patent with the machines brought over and about to be used by me and the mechanism of my machines is substantially that as set forth and described in the Wright patent." * * *

Witness my hand, and the seal of the United States District Court for the Southern District of New York, this 15th day of January, 1912.

2196 THOS. ALEXANDER,

[SEAL.] Clerk.

Defendant's Exhibit "Hamilton Lease."

LEASE made this seventeenth day of November, 1909, between Glenn H. Curtiss, of Hammondsport, N. Y., and Charles K. Hamilton, of New Britain, Conn.

WITNESSETH:—Whereas the said Curtiss desires to advance the interests, not only of himself as an exhibitor of the Herring-Curtiss Company aeroplane, but to advance the sales of the said aeroplane for the Herring-Curtiss Company,

now therefore in consideration of the rents and 2197
covenants hereinafter expressed, the said Curtiss hereby leases to the said Hamilton one of the said Herring-Curtiss Company aeroplanes upon the following terms and conditions for the term of two years from the date of this instrument, and the said Hamilton hereby agrees to make exhibition flights with said aeroplane at such places and times as from time to time shall be designated by said Curtiss, or by the lawful representative of said Curtiss; And the said Hamilton shall pay to the said Curtiss, as rent for the use of said aeroplane, a sum equal to sixty per cent. of the
net proceeds of each and every contract for 2198
exhibition, which shall be fulfilled by said Hamilton, such rent to be due and payable as fast as the price for such exhibitions shall be paid. The net proceeds of each and every contract which shall be fulfilled by said Hamilton, shall be determined by deducting from the gross proceeds of said contract all the proper expenses of transporting the aeroplane to the place of making the exhibition flight, the expense of transporting the said Hamilton and his necessary mechanics, who shall assist him in preparing for said flights, the expense of all fuel for the aeroplane and all
other expenses incident to the maintenance and 2199
repair of the aeroplane while being used by said Hamilton under this lease. The foregoing are the expenses to be deducted from the gross proceeds in order to determine the net proceeds, which net proceeds are the basis from which the aforesaid rent is to be determined. The said Hamilton shall pay forty (40) per cent. of all expense of replacing any or all parts of the areoplane used by said Hamilton, whenever the replacing of any or all the parts of said aeroplane shall be required because of an accident occurring to said aeroplane while in the care of said Hamilton.

2200 In order that the reputation of said aeroplane and said company, which manufacture it, may be maintained and increased, the said Hamilton agrees that he will fulfill in good faith and diligently each and every contract for exhibition flights, which shall hereafter be made at any amusement park or fair, which shall be signed for each and every date, the said Hamilton to have the first opportunity to fulfill any other contracts or agreements, which the said Curtiss may not care to fulfill personally.

It is further agreed that until March 1, 1910, the said Hamilton will fill each and every contract
2201 for exhibition flights intended for amusement purposes solely, for which admission fees are charged, the said Curtiss not binding himself to turn over to said Hamilton for fulfillment contracts having a special object aside from exhibition features.

The said Hamilton agrees to faithfully and diligently fulfill his part of this contract and lease, and he also agrees to furnish to said Curtiss, by December the first, 1909, a good surety company bond, satisfactory to said Curtiss, for the sum of five thousand dollars for the payment of all rent which shall accrue under this lease, and
2202 during the existence of this lease and contract and for the collection of all moneys authorized by the said Curtiss.

In case the said Hamilton shall fail to fulfill the terms of this contract, and the conditions and terms of said lease, then at the option of said Curtiss, the said lease shall end, and the right of said Hamilton to operate under this contract shall also cease, upon Curtiss giving sixty days notice to said Hamilton.

The said Hamilton agrees that he will not sell his services professionally and that he will not permit the use of his name in connection with any other aeroplane but that which shall be leased to him by the said Glenn H. Curtiss or designated by the said Curtiss as a substitute for the leased machine. 2203

IN WITNESS WHEREOF, the parties hereto have subscribed their names and affixed their seals in duplicate, the day and year first above written.

Chares K. Hamilton [L. S.]
G. H. Curtiss [L. S.]

Defendants' Exhibit Mattullath's Application. 2204

UNITED STATES OF AMERICA

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the Records of this Office of the Petition, Specification, Oath, and Drawings, as originally filed, in the matter of

Abandoned Application of 2205

Hugo Mattullath,

Filed January 8, 1900, Serial No. 751

for

Improvement in Flying Machine;

said Hugo Mattullath now deceased, Meta Mattullath, Administratrix of his estate.

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the patent office to be affixed at the City of Washington, this 29th day of October, in the year of our Lord one thousand nine hundred and nine and of the

2206 Independence of the United States of America the one hundredth and thirty-fourth.

F. A. TENNANT,
[SEAL.] Assistant Com. of Pats.

PETITION.

To the Commissioner of Patents:

Your petitioner Hugo Mattullath a citizen of the United States, residing at Detroit in the County of Wayne, State of Michigan, whose Post Office address is Detroit, Michigan, prays that Letters-Patent may be granted to him for the improvements in Flying Machines as set forth in
2207 the annexed Specification.

And he hereby appoints BARTHEL & BARTHEL (Adolph Barthel and Otto F. Barthel) of Detroit, Michigan, whose registry number is 2510, his attorneys with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the Patent, to sign the drawings, and to transact all business in the Patent Office connected therewith.

Signed at Detroit, in the County of Wayne and State of, Michigan, this 23rd day of December 1899.

2208 HUGO MATTULLATH

SPECIFICATION.

To all whom it may concern:

Be it known, That I, Hugo Mattullath, a citizen of the United States of America, residing at Detroit in the County of Wayne, and State of Michigan, have invented certain new and useful improvements in Flying Machines of which the following is a specification, reference being had therein to the accompanying drawing.

The object of my invention is to construct a

flying machine capable of commercial application 2209
for the transportation of goods and passengers.

The fact that no successful flying machine of this character has ever been constructed proves nothing against the feasibility of such an undertaking. Enough has been accomplished up to the present day to demonstrate the possibility of dynamic flight upon the principle of the areoplane propelled at an angle to the direction of flight.

My invention is based upon this principle, and I believe I have overcome the mechanical difficulties heretofore in the way. The principal considera-
tion which has guided me in my construction is 2210
that dynamic flight is predicated upon the question of speed.

A practical flying machine must be entirely independent of the movement of the air in order to be able to fly in any direction at the will of the navigator. As we may encounter headwinds blowing at the rate of 60 miles per hour, the flying machine should be able to fly at a speed of 100 miles in quiet air in order to travel at the rate of 40 miles against such a headwind. My improvements are intended to make such speed possible by providing an efficient flying organ
and further by so shaping and arranging the parts 2211
as to reduce the head-resistance to a minimum.

My invention also embraces certain novel features of construction for insuring the stability of the device for steering it in any direction at the will of the operator and for rising from the ground and for landing, all as more fully hereinafter described and shown in the accompanying drawings, in which,

Fig. 1, is a longitudinal vertical section substantially on lines x-x Fig. 2 and u-u- Fig. 4,

Fig. 2, is a horizontal plan below the line y-y in Fig. 1.

Fig. 3 is a horizontal plan below the line z-z in Fig. 1.

2212 Fig. 4 is a vertical cross-section substantially in line v-v Fig. 1.

Fig. 5, is a detached, enlarged plan of one of the revolving disks which constitutes the flying element.

Fig. 6, is a section of Fig. 5 on line w-w.

Fig. 7, is a section on line s-s Fig. 5.

Fig. 8 is an elevation of the cam track which guides the wings.

Fig. 9, is a side elevation showing the construction of the separate stanchions, and

Fig. 10, is a cross-section thereof.

A A are two boat-shaped cars extending the whole
2213 length of the flying machine or nearly so and affording sufficient interior room for housing the motive power, equipments, passengers and baggage. These two cars are united together parallel to each other in the form of a catamaran by means of a lower deck B. The underside of this deck between the vessels A A constitutes one of the aeroplanes and is intended in the normal horizontal flight of the machine to impinge against the air at an angle of about two to three degrees while the top or upper surface of this deck extends from the point *a* where it intersects at the forward end with the lower surface back to a point *b* in a horizontal plane and
2214 then continues to the rear end in parallelism to the under surface. In this way a material aeroplane is obtained which presents no head-resistance to the air at the forward end while at the same time an enclosed space or housing is obtained between the upper and lower surfaces to conceal therein suitable transverse beams and other structural parts required to give the deck the necessary strength and stiffness without resorting to exterior parts which would create resistance.

C are movable aeroplanes overhanging the sides of the cars A. They are secured to shafts D journaled in suitable bearings and are adapted to be set

at any desired angle by means of levers D′ or other 2215
suitable means under control from within the cars.

E is an upper deck substantially extending in
all directions over the lower structure and sup-
ported thereupon by stanchions E′. This upper
deck is substantially constructed after the same
plan as the lower deck B, that is, the underside
thereof constitutes an aeroplane which in the nor-
mal flight of the machine is intended to travel
against the air at an angle of about 2 to 3 degrees,
while the upper surface is substantially upon a
horizontal plane intersecting at the point *c* at the
forward edge with the under surface and running
back sufficient to form a housing between the upper 2216
and lower surfaces for concealing therein the struc-
tural parts necessary to obtain a stiff and rigid
structure without any external structural feature
beyond the supporting stanchions.

This upper deck E is constructed with circular
portions F which are rotatorily supported within
corresponding openings in the deck. These disk
shape portions F are adapted to be revolved by
means of upright shafts G and are supported within
the openings of the deck free to revolve by means
of wheels H which travel on suitable circular ways
H′ in the circular openings of the deck and each
disk is provided with a series of wings L secured to 2217
radial shafts J. The shafts J project beyond the
disk and terminate in cranks K which are guided
upon a circular cam track M located within the
openings in the deck. The wings L extend in oppo-
site directions from the shafts J and are adapted
to be extended above and below the disk as shown in
dotted lines in Fig. 1, during a portion of the revo-
lution of the disk and are folded flat against the
upper and lower side of the disk respectively dur-
ing the remaining portion of the revolution by the
action of the cam groove M. This cam groove is
formed on a ring N which latter may be rotatorily

2218 adjustable by means of the pinion *d* meshing with a circumferential gear *e* on the periphery of the ring.

Above the deck E are supported the aeroplanes O preferably arranged in separate groups placed fore and aft and on opposite sides. These aeroplanes are constructed in the same manner as already described for the other aeroplanes, that is to say, they present a sharp edge at the forward end and all the structural parts necessary to give material strength and thickness are concealed within the upper and lower surface. These aeroplanes are supported on suitable stanchions P to which the
2219 aeroplanes are secured in any suitable manner which permit of their being adjusted to various inclines within the limit of a few degrees.

The stanchions which support the different planes are also made to prevent head-resistance and are composed of board-like uprights *f* of the cross-section shown in Fig. 10, and two or more are secured together in vertical longitudinal planes by means of transverse members *g* placed at short intervals apart and at inclines as shown so as to act likewise as lifting planes.

Q is a rudder secured on a vertical shaft R and
2220 extending above and below the deck E substantially the whole height of the superstructure above the cars.

The under surface of the aeroplanes (which is the aeroplane proper) is to be constructed in a material manner to have in connection with the superimposed frame the necessary strength and rigidity to withstand the lifting pressure of the air, the upper surface may be formed by a mere covering or roof, it receives no air pressure to speak of, but adds strength to the whole by being structurally united to the lower plane. The space between is hollow except as it is occupied by the framing. By this construction I have practically eliminated the factor of head-resistance, by which I mean such 2221 resistance which has a more retarding effect, without such provision it would be under present conditions impossible to carry enough power to propel the machine at the speed desired.

Next to head-resistance the principal factor which consumes power depends upon the angle at which the aeroplanes must be pitched to produce the necessary lifting power. I chose as small an angle as possible, the smaller the angle however the larger the planes would have to be and to keep within practical limits as to size which means weight, I believe I can fly upon an angle of less than 3%. 2222 The weight of course is an ever present factor to be considered, but with a full exercise of the skill we possess at the present time to frame structures requiring the utmost degree of lightness combined with strength I will be able to build the structure within the limit of the weight I will be restricted to.

Size is also a factor not only from the point of stability, but also on account of the increased feasibility of the larger structure to meet the practical requirements. I contemplate to build it on a scale of about 180 feet of length over all which would make the revolving disk about 40 feet in diameter. 2223

With this conception as to the requirements as a basis, the proper amount of surface which the aeroplanes must be given and the pitch required at which they will support the weight, are matter of arithmetical calcul and so is the amount of power, size and speed of wings and all other factors, and with well matured plans the probability of a successful solution of the problem in accordance with my invention can be ascertained beforehand.

In my construction the disks which carry the wings are directly embedded in and supported by

2224 an aeroplane thus avoiding all head-resistance and protecting the flying organ from the effects of vibration and shocks due to high speed as well to other causes. They form an important factor in maintaining the stability of the structure during flight, on account of the high speed with which they will revolve.

The cam track which guides the wings has no abrupt turns, each wing will be gradually opened as it passes to the outside-half of the circle and after having passed about 1/6th thereof it has become opened to an angle of about 70° and remains so until it has passed another 1/6th of the
2225 circumference when it begins to fold back again. The possibility of adjusting the cam tracks by turning the rings N provides a means for steering which under certain circumstances may be desirable, for like reasons I also prefer to drive each disk with a separate engine.

The adjustability of the aeroplanes O and their arrangement in groups fore and aft and to opposite sides of the longitudinal center permits of trimming the structure for its normal flight, while the movable aeroplanes C, which are in charge of a trained crew are for steering the machine in the vertical plane as well as for maintaining the stability.

2226 By having two long and widely separate cars which also represent the greater portion of the weight great lateral stability is gained in flying and at the same time it permits of rising from and landing on the water. The art of flying such a machine will have to be learned, the parts will have to be adjusted and tried, a crew will have to be trained and all this and other preliminary work will have to be done before actual flight can be attempted, with my construction all this can be safely done on the water in connection with a suitable towing vessel or other speeding device.

For starting on solid ground and landing thereon, I intend to place suitable wheels under the cars. 2227

To reduce the head-resistance to a minimum, I place a wedge-shaped guard or shield in front of every part of the structure which from its inherent shape would create air-resistance. Thus the exposed portions of shafts have a double wedge-shaped shield placed over them as shown in dotted lines in Figs. 3 and 5. This shield may be made fast in position or may be sleeved upon the shaft to turn freely like a vane.

As the construction of the frame of the aeroplanes involves nothing more than mechanical skill 2228
to come within the requirements of my invention, I deem it unnecessary to further describe it, as a skillful construction of all the parts of the structure.

WHAT I CLAIM AS MY INVENTION IS:

1. In a flying machine, an aeroplane formed with a lower plane surface inclined at an angle to the plane of flight and an upper surface forming with the under surface a wedge-shaped junction in the horizontal plane of flight.

2. In a flying machine, an aeroplane having an 2229
upper and lower surface formed of separate planes structurally united together by a supporting frame inclosed wholly in the space formed between said planes, the plane forming the lower surface or aeroplane proper being inclined at an angle to the horizontal plane of flight and the plane forming the upper surface or roof being wholly or partly in the horizontal plane of flight and forming with the lower plane a wedge-shaped junction at the forward end.

3. In a flying machine, the combination with the

2230 supporting car or cars and the aeroplanes mounted thereon, of supporting stanchions composed of vertical uprights of wedge-shaped cross section united at a distance apart by a vertical series of transverse members constituting aeroplanes.

4. In a flying machine, a flying organ composed of an imperforate rotary disk or wheel and a series of folding wings secured to radial shafts radially journaled in said disk and adapted to fold the wings against the sides of the disk.

5. In a flying machine, a flying organ composed of an imperforate disk peripherally supported in
2231 a horizontal plane and provided with a shaft for revolving it, and folding wings carried by the disk and adapted to fold against the sides of the disk.

6. In a flying machine, a fixed aeroplane combined with a flying organ composed of a revolving disk peripherally supported in a circular opening in the aeroplane and provided with folding wings.

7. In a flying machine, the combination with a fixed aeroplane, of a revolving disk supported in a circular opening in said aeroplane and forming a complementary part thereof, said disk carrying the flying members or wings.

2232

8. In a flying machine, a fixed aeroplane combined with a flying organ composed of a revolving disk or wheel peripherally supported in a circular opening in the aeroplane and provided with folding wings, said disk and aeroplane having coincident upper and lower surfaces formed with a wedge-shaped junction at the front end of the aeroplane.

9. In a flying machine, the combination of a fixed aeroplane of a series of revolving disks supported in circular openings in said plane in longitudinal

rows on opposite sides of the longitudinal center thereof, said disk carrying the flying elements or wings. 2233

10. In a flying machine, a fixed aeroplane combined with a plurality of flying organs each composed of a revolving disk peripherally supported in a circular opening in the aeroplane and provided with folding wings, said disks being arranged in series on opposite sides of the longitudinal center of the aeroplane and forming complementary parts thereof.

11. In a flying machine, the combination with a fixed aeroplane, a revolving disk supported in a circular opening in said aeroplane, a circular track in said opening, supporting wheels carried on the periphery of the disk and supporting said disk on said circular track and wings carried by the disk. 2234

12. In a flying machine, the combination with a fixed aeroplane, a revolving disk supported in a circular opening in said plane, a series of wings upon radial shafts journaled in said disk, a crank arm on the outer end of each shaft, and a cam track in the circular opening with which said crank arm engages to open and close said wings.

13. In a flying machine, the combination of a fixed aeroplane, a revolving disk supported in a circular opening of the disk and carrying folding wings and a cam track in the circular opening of the aeroplane for opening and closing the wings by the movement of the disk, said cam track provided with means for shifting it around the center of the disk. 2235

14. In a flying machine, the combination with the fixed aeroplanes, of pivotally adjustable aeroplanes arranged in series one behind the other from front to rear on each side of the flying ma-

2236 chine and adapted to cooperate with the fixed aeroplanes and to vary the lift on opposite sides and front and rear.

15. In a flying machine of the character described, the herein described means for promoting its lateral stability the same consisting in supporting it upon its sides on two boat-shaped cars extending longitudinally of the flying machine and in dividing equally between them the principal part of the weight.

16. In a flying machine of the character described, the herein described means for maintain-
2237 ing its lateral stability, the same consisting in supporting it upon its sides on two boat-shaped cars extending longitudinally thereof and dividing equally between them the principal part of the weight in combination with two series aeroplanes carried along the outer sides of said cars, one on each car and adapted to be individually adjusted to different angles with the plane of flight.

17. In a flying machine, the combination of two cars, united at a distance apart by a suitable frame or deck, a fixed aeroplane supported above said frame or deck inclined at an angle to the horizontal
2238 plane of flight and a series of revolving disks supported above the cars in circular openings in said plane and carrying the flying elements or wings.

18. In a flying machine, the combination of two cars united at a distance apart by a lower deck, a fixed aeroplane supported above said lower deck and a series of revolving wheels supported above the cars in circular openings in said aeroplane and carrying wings, each wheel being secured to upper ends of a shaft extending down into a car and having the power applied at its lower end.

19. In a flying machine, the combination of two boat-shaped cars, a lower deck uniting the cars and constituting an aeroplane, an upper deck freely supported upon stanchions above the lower deck and forming an aeroplane, aeroplane adjustably supported above the upper deck in separate groups, a series of aeroplanes carried on the sides of the cars and forming means for steering by adjusting them to different angles, and a series of revolving wheels supported in openings in the upper deck and constituting active flying organs. 2239

20. In a flying machine, the combination of two boat-shaped cars, a lower deck uniting the cars and constituting a fixed aeroplane, a series of aeroplanes carried on the sides of the cars on outwardly projecting shafts having means within the cars for adjusting the planes to different angles, an upper deck extending over the lower deck and above the same and constituting a fixed aeroplane, a series of revolving disks, supported in openings within said upper deck and carrying wings, a series of aeroplanes adjustably supported in position above the upper deck and arranged in groups fore and aft and on opposite sides of the longitudinal center and a vertical steering rudder. 2240 2241

In testimony whereof I affix my signature in presence of two witnesses.

Hugo Mattullath.

Otto A. Barthel,
Jos. A. Noelke.

OATH.

City of Detroit,
County of Wayne, } ss.:
State of Michigan,

Hugo Mattullath, the above named petitioner,

2242 being duly sworn, deposes and says that he is a citizen of the United States of America, and resident of Detroit, in the County of Wayne, and State of Michigan, and that he verily believes himself to be the original, first and sole inventor of the Improvement in Flying Machines described and claimed in the annexed specification; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof; or patented or described in any printed publication in any country before his invention or discovery thereof, or more than two years prior to this application, or in public use
2243 or on sale in the United States for more than two years prior to this application, and that no application for patent on said improvement has been filed by him or his representatives or assigns in any foreign country, except as follows:

HUGO MATTULLATH.

Sworn to and subscribed before me
this 23rd day of December, 1899.

Otto A. Barthel,
(Notarial Notary Public,
Seal.) Wayne Co., Mich.

2244

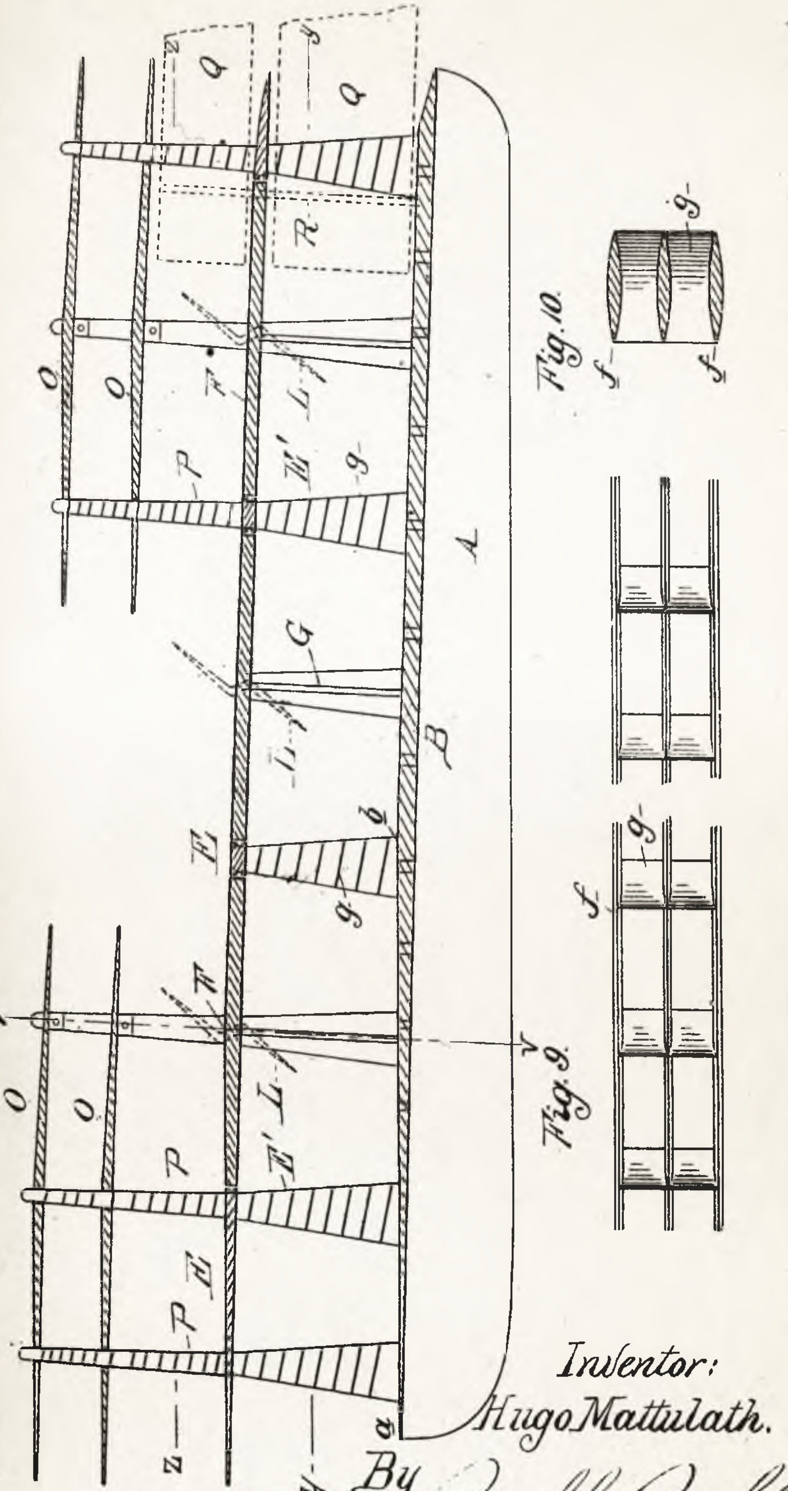


Fig. 1.

Fig. 9.

Fig. 10.

Witnesses:

Jos. G. Noelk

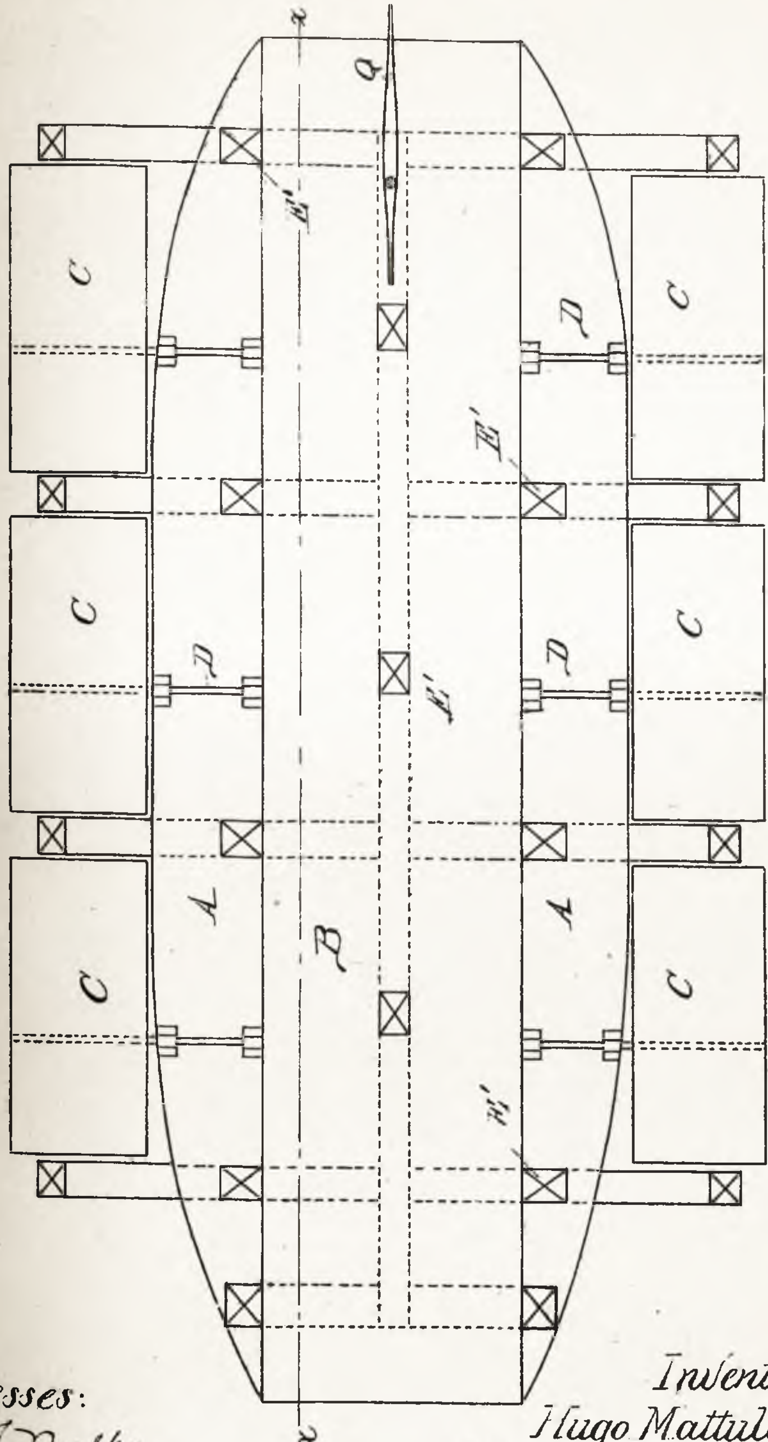
J. M. Schowalter

Inventor:
Hugo Mattulath.

By Baukee & Baukee

Attorneys.

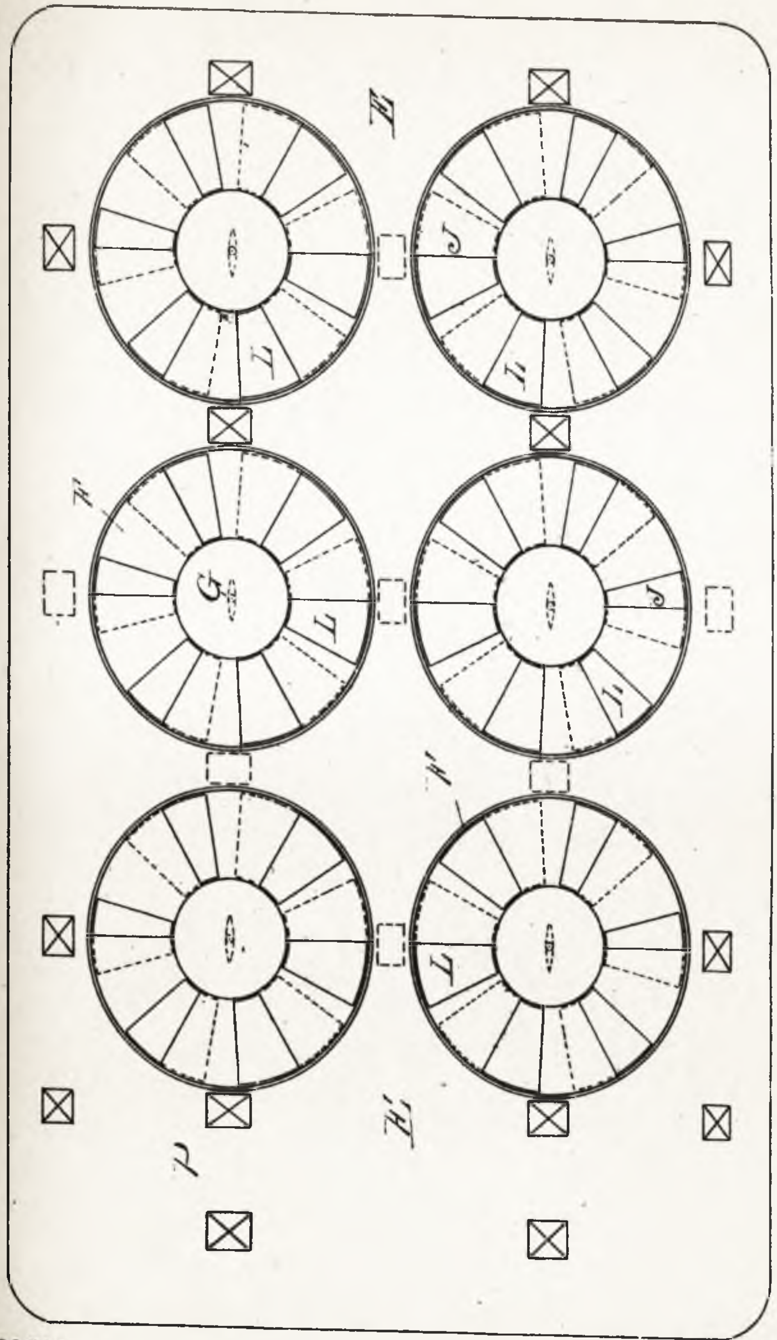
Fig. 2.



Witnesses:
Jas. G. Noelke
J. M. Abowalter

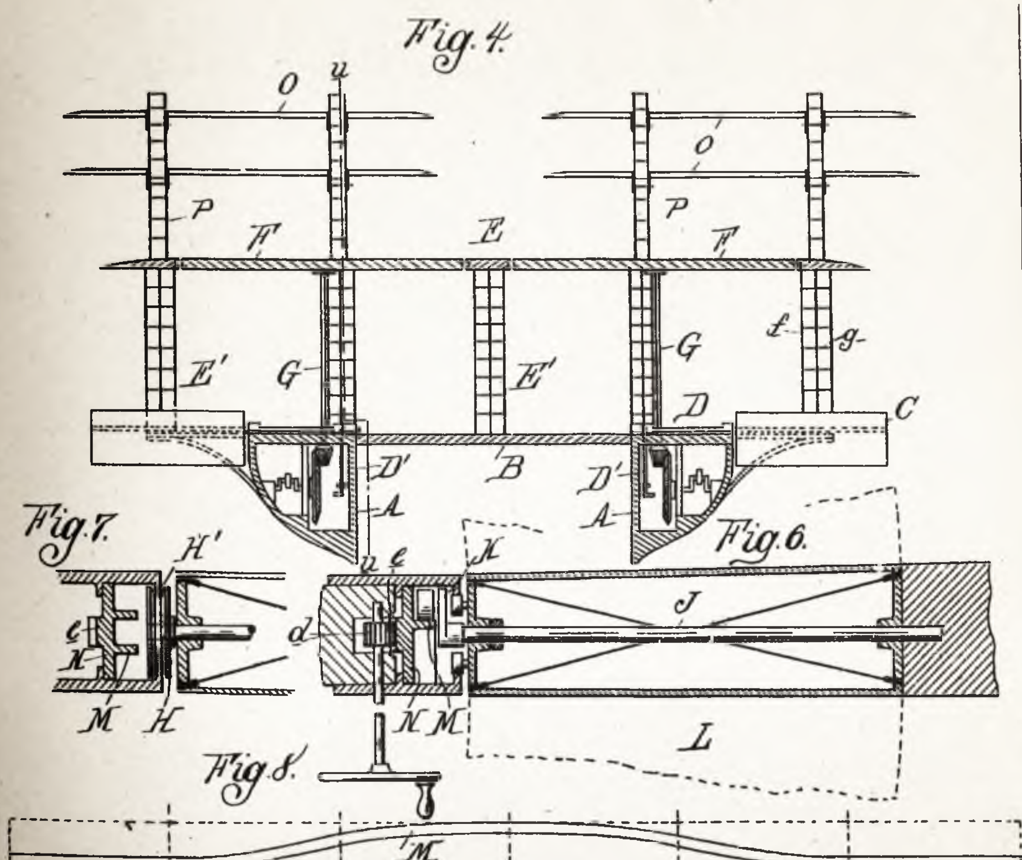
Inventor:
Hugo Mattullath
By Bartlett & Bartlett
Attorneys.

Fig. 3.



Witnesses:
Jos. A. Noelke.
J. M. Showalter

Inventor:
Hugo Mattullath,
By [illegible]
Attorneys.



Witnesses:
Jos. A. Noelke
J. M. Schmalter

Inventor:
Hugo Mattullath
By
Attorneys.

Defendant's Exhibit "Court of Appeals Mattullath Opinion." 2257

In the Matter of The Application of META MATTULLATH, Administratrix of Hugo Mattullath.	Patent Appeal, No. 751.

On January 8, 1900, Hugo Mattullath filed an application for a patent for a flying machine. His 2258
home was then in the City of New York, where his family then, and has since resided. At the time of filing the application he was in the City of Detriot, Michigan, and gave a power of attorney to Barthel & Barthel, patent solicitors, having an office in that City, to represent him. The power of attorney was filed with the application and the same was prosecuted by the solicitors in connection with their associate in the City of Washington. On March 10, 1900, objections were made by the Examiner, in which he pointed out many formal defects, suggesting changes, amendments, etc. In the body of this communication he said: 2259

"The construction is regarded as inoperative for the purpose intended and therefore not useful within the meaning of the Patent Law. No successful attempt has yet been made to rise from the earth's surface by means of an aerial vessel unprovided with a baloon. The results of previous experimentation indicate that even if the rising could be successfully accomplished, the vessel would be uncontrollable through inability to maintain its normal position or balance. Minor difficulties lie in

2260 the apparent inadequacy of the propelling means acting against the air to insure such speed either in the air or in water as is needed to give the aeroplanes sufficient lifting power. Applicant has disclosed no new principle or construction which would on its face exempt his device from the difficulties by his predecessors in this line. However plausible applicant's theory may be, in view of the present state of the mechanic arts and the results of previous experimentation the step is so long from the theory to actual use, and the practicability of his apparatus is so problematical that actual demonstration of operativeness will be re-
2261 quired before the grant of a patent."

The communication was responded to April 9, 1900 by the Washington solicitor in a communication proposing amendments, and arguing in favor of general patentability. A communication from the Examiner, dated May 16, 1900, objected to certain claims, allowing one, and suggesting amendments to others. In conclusion he added: "The former criticisms as to the showing, etc., are repeated." Other amendments were offered during 1901 and 1902, and the Examiner, on October 1, 1902, sent a communication, rejecting claims 1 and 2 on references, suggesting amendments to claims
2262 15 and 16, and that claims 21-22 and 23 appear to be allowable. In conclusion he said: "The rejection on the ground of inoperativeness and consequent lack of utility is adhered to." The correspondence took place between the Washington solicitor and the Examiner. Sept. 18, 1903, the solicitor filed formal amendments in an attempt to comply with the last notice of objections. Sept. 29, 1903, the Examiner made the following indorsement on the application for amendment, signing his name there-

to officially: "This application as amended Sept. 18, 1903 has been considered. An amendment has been received in this case, but no action can be taken upon the merits thereof for the reason that the applicant's death operates as revocation of the power of attorney to Barthel & Barthel and there is no one of record authorized to prosecute the case." 2263

There is no suggestion of the death of the applicant in the record, and how knowledge thereof came to the Examiner is not shown. The transcript of the proceedings in the office does not show the fact, but it appears from the affidavits filed in the prosecution renewal that a letter was ad- 2264
dressed to Barthel & Barthel notifying them of the revocation of their power of attorney by the death of the applicant. It appears in the same way that Hugo Mattullath died in Washington Dec. 30, 1902. It appears from the office trascript that a letter was filed Aug. 14, 1909, from the Washington solicitor giving permission to Professor Zahm, to inspect the application and drawings on file.

Oct. 19, 1909, Meta Mattullath who had received letters of administration upon the estate of her deceased husband, Hugo Mattullath, executed a power of attorney to one R. E. H. Starr of New York, authorizing him to represent her in 2265
the Patent Office, which was filed and accepted Nov. 5, 1909, and Starr was so notified Nov. 6th. Sept. 16, 1910, she executed another power of attorney to Joseph F. O'Brien which was filed in the Office. On Nov. 22, 1910, O'Brien filed a short amendment of the original application cancelling claims 1 and 2 and formally amending claims 15 and 16 by inserting the "of" as suggested in the before mentioned communication of the Examiner, dated Oct. 1, 1902. The appli-

2266 cation was entered on the office records as abandoned Oct. 3, 1903. On Nov. 23, 1910, Meta Mattullath filed a petition to revive. In this she alleged that her husband lived in New York and died in Washington Dec. 30, 1902, leaving petitioner, his widow, and three daughters. That she had been duly appointed administratrix of his estate. That while she and other members of his family knew that intestate had worked on an invention of flying machines, none of them had knowledge of the existence of the said application until about Oct. 13, 1909, when informed by an attorney in New York, who called to request
2267 her to sign an instrument authorizing him to have access to said file. Said authority was given to Mr. Newell, but subsequently she executed a power of attorney to R. E. H. Starr, revoking the former one. That intestate left no estate whatever, and petitioner was destitute, and being supported by her children. Mr. Starr consented to act for her without fee, if she could advance money for necessary disbursements. That she managed to pay him forty-one dollars for the purpose, and he agreed to make application to revive the application for patent. That petitioner believed that application had been made. She
2268 has since learned that no application was made by Mr. Starr on account of severe illness, which finally resulted in his death. Shortly before his death she wrote to him to return her papers in case his illness was so serious that he could not prosecute the business promptly. Receiving word that he was unable to proceed, petitioner undertook to recover her papers, among them, copies of Patent Office proceedings which Starr had obtained with the money advanced by her. That

these papers were scattered and could not be 2269
obtained. Petitioner then undertook to procure the services of others and among them considered Barthel & Barthel, but learing that they had written to Mr. Starr wanting $100.00 per day, she did not communicate with them. After some delay she succeeded in securing the services of Mr. O'Brien who agreed to represent her without compensation. That she is informed that an amendment to the application was prepared by Barthel & Barthel, or their Washington Associate, after the death of her husband and that the same was refused on the ground that his death had revoked their authority. That she was never 2270
notified by said attorneys of said action; and had she been would certainly have ratified the act of said attorneys in filing the amendment and have endeavored to prosecute the application. That neither she nor her children knew that her husband had an application pending, and in fact did not know that there was a difference between an application for a patent, and a patent. That they thought, from his efforts in the matter of air-ships that her husband had some kind of a patent, but upon investigation found that such patents as he had had been assigned to other parties. This petition to revive the application 2271
was sworn to by the petitioner and supported by affidavits of each of the children of intestate, and a son-in-law. An affidavit by the confidential clerk of Mr. Starr, Rose V. Finn, corroborated petitioner as regards the employment of Mr. Starr, and gave the details of his sickness, of his attempt to attend to the revival of the application, of his being compelled to leave his office, and removal of some of his papers to his father's

2272 home; of the communications from petitioner regarding the business, and Mr. Starr's expression of the belief that he would be strong enough to prosecute the business. She also stated that when a suggestion was made to him to give the business up, his reply was that petitioner had no money to employ another attorney, and that he would soon be able to attend to it. A few days before his death, he realized his condition, and then notified petitioner and instructed that her papers be surrendered. Affiant searched for copy of the application and file wrapper, but was unable to find them. Mr. Starr died of tuberculosis and

2273 neuritis on Sept. 8, 1910. The affidavit of Joseph F. O'Brien, the succeeding attorney, was to the effect that as soon as employed he began the search of papers supposed to have been in Starr's possession, and succeeded in obtaining a letter of Wilbur F. Wright from Mr. Starr's father. The certified copy of the application and file wrapper could not be found and he was compelled to obtain the same from the Patent Office, which he received about ten days or two weeks before filing the petition to revive. To this affidavit is attached the following letter from Wilbur F. Wright:

2274

College Park, Maryland,
14 October, 1909.

Miss Alice Mattullath, New York,

Dear Madam:—

I thank you for your very kind letter of 29th, Sept., which I have found it impossible to answer hitherto. I had already arranged a canoe to float the machine, in case of coming down, so could not try the raft you were so kind as to suggest and offer, but I very much appreciate the friendly spirit which prompted you. 2275

I knew a little of your father's work through conversation with Professor Zahm and others, but he had died before my brother and I had really begun our work.

With many thanks and best respects,

Yours truly,

WILBUR WRIGHT.

The following letter from Barthel & Barthel, to Mr. Starr, was also attached:

"Detroit, Mich., Nov. 20, 1909. 2276

Mr. R. H. E. Starr, 280 Broadway,
New York, N. Y.

Dear Sir:—

In reply to your favor of Nov. 13, *re* Mattullath, would say that we believe the same discloses at least some of the fundamental principles of the aeroplane.

In reference to the various points covered in your letter would say, first, when we received the Patent Office letter notifying us that the death of the applicant had operated as a revocation of our power, we believed that we notified no one, 2277
as we did not know the address or whereabouts of the widow. Second, as far as we know there was no agreement in existence between the applicant and other parties unless it might possibly have been parties in Pittsburgh or Prof. Langley or Zahm with whom he had consulted considerably while in Washington. Third, we have no copy of any agreement or other document which could show any interest in any outside party.

2278 We could verify the above points fully upon making a proper search through our office records.

It is our recollection that at the time of Mr. Mattullath's death he was in or near Washington and we had given him the address of our Washington associate, and that at the time of his leaving here he gave us no address where we could reach him.

We received a notice from the Patent Office revoking our power of attorney and do not believe that the family knew anything of the existence of this application as Mr. Mattullath was very secretive in connection with work on this invention.
2279 Our charges as attorneys would be $100.00 per day and expenses. * * * Mr. Mattullath was a frequent caller upon us during the preparation of this application and might state that he spent weeks at a time in and about our office in connection with this matter." * * *

(Signed.) Barthel & Barthel."

The petition came before Assistant Commissioner Tennant, who denied it in a decision entered March 25, 1911. The grounds of his decision are fairly represented in the following extract from his opinion:

2280 "It is urged in support of the petition that the delay in amending this application within the period allowed by law was unavoidable, for the reason that the administratrix was wholly unaware of the pendency of the application until Oct. 13, 1909, and that thereafter she did all within her power and financial means to obtain the revival of this application and resumption of its prosecution. It is urged that the ground of inoperativeness or lack of utility which was the

basis of the objection was removed at the time it 2281
was first demonstrated that aeroplanes could be successfully flown and managed in flight, and it is insisted that the Mattullath machine embodies the same principles as those machines which are in successful flight at the present time.

Although the path of the administratrix of the estate of Hugo Mattullath, as appears from the affidavits, has since Oct., 1909, been strewn with obstacles, I am clearly of the opinion that the showing is insufficient to establish unavoidable delay for the entire period since Oct., 1903, in the circumstances attending this case. The application was
filed in the early part of 1900, and a patent was re- 2282
fused upon the ground that no heavier than air machines of this character had ever been successfully flown and that therefore the invention lacked utility. There is no showing in the record that any attempt was ever made by this applicant to overcome this ground of rejection, although the case was pending over two years before the death of the applicant. It appears from the affidavit of the administratrix, Mrs. Mattullath that as early a date as her marriage with Hugo Mattullath, which occurred in the year 1868, she was aware that her husband was studying aeronautics and intended to
build a flying machine." 2283

(It is to be observed that while this required demonstration of operativeness was insisted upon, the office had been, commendably, permitting and aiding in the formal perfection of the claims, preliminary to the final demonstration of utility, which formal perfection had not been completed and was attempted in the last amendment filed Sept. 18, 1903.)

2284 Petitioner renewed her petition for hearing before the Commissioner. It is in the nature of an application for a rehearing. In support of this petition she filed an elaborate affidavit stating particularly, her efforts to obtain information. She said that her husband left Detroit on May 10, 1900, for Washington and only occasionally visited New York City. Unable to learn anything about his interests, she consulted Kaufman Simon, an attorney and friend, who advised her to communicate with all parties known to have been closely associated with her husband, who might know anything of his affairs. Accordingly in Jan., 1903, she wrote
2285 to Charles H. McKee and Frank Moore of Pittsburgh, and Professor Zahm and Mr. Brown of Washington, who were believed to know something of her husband's work, inquiring if he had left any patents or anything in any shape or form of value. No reply was received from McKee or Moore; the letter to Brown was returned from the Washington Post Office. Prof. Zahm replied that he did not know of Mattullath's having any patent on flying machines, and so far as he knew there was nothing of value left by him. Affiant did not know of the Detroit attorneys, had never heard of or from them, and hence could not apply to them. She further
2286 said that she knew nothing of patent procedure, and supposed that matters in the Office were inviolably secret; and did not know that she could have access to the records. Nor did she have any information that suggested any inquiry, or any means to employ any one to make inquiries; and that she had no idea that a patent application was pending. A supporting affidavit by petitioner's son-in-law corroborated her affidavit respecting the

letters, and the want of knowledge, etc. An affidavit by Kaufman Simon supported petitioner's statement as regards his advice, and the letters that were written. The Commissioner denied the petition July 13, 1911. After reciting the proceedings in the Office proceeding the entry of abandonment, the Commissioner said: 2287

"No other action was taken by or on behalf of the applicant until Nov., 1910, over seven years after the period allowed by law for such action had expired, when the original petition to revive was filed. In the meantime dynamic flight, the age long dream of man, had become an accomplished fact. Others had succeeded in actually flying in heavier-than-air machines, had obtained patents on their inventions, and were reaping the just rewards of their efforts. But for this fact the present application would doubtless have remained neglected for all time, since it appears that the present petitioner, Meta Mattullath, the administratrix of the applicant, learned of it only through parties who sought to use it in connection with the defence of a suit brought by Wilbur and Orville Wright on their patent No. 821,393. 2288

Under these circumstances, it might well be held that the presumption is conclusive against the existence of acceptable excuse for such delay as occurred in this instance; certain it is that an application so long dead can be revived, if at all, under the provisions of Section 4894 of the Revised Statutes only upon a showing of most unusual and compelling circumstances, rendering it impossible to have earlier prosecuted the case. To hold otherwise, would be to encourage those who had slept upon their rights while others struggled on to success to now enter the field and wrest from them the fruits of their labor." 2289

2290 In this statement he treats the last action in the Office as having been taken Oct. 2, 1902 instead of Oct. 1, 1903, which made the delay seven years instead of six.

From this decision the appeal has been prosecuted.

1. The right to appeal from a final decision of the Commissioner of Patents is determinable by its substance and effect, rather than its form. Moore *v.* Heany, 34 App., D. C., 31-39; *In re* Selden, 36 App. D. C., 428-431. The appeal in Selden's case was from a decision holding that the
2291 application had been abandoned for lack of prosecution within two years. The right to appeal was maintained. Discussing the point, Mr. Justice Robb delivering the opinion of the Court, said: "The question, then, is whether the striking down of an application on the ground of abandonment amounts to a rejection of the claims thereof within the meaning of the statute. Of course, if such action on the part of the Commissioner is in effect a rejection of the claims of the application, the Court will look to such result rather than to the manner in which it is reached. Substance should not be sacrificed to form." In that case, as in this,
2292 the lapse of time rendered the order tantamount to a complete rejection of the claims, as a new, original application would be practically unavailing.

2. Section 4894 R. S. governs the abandonment and renewal of applications for patents. It requires that all applications for patents shall be completed and prepared for examination within one year after filing, and in default thereof, or upon failure to prosecute the same within one year after any action therein, of which notice shall have

been given to the applicant they shall be regarded as abandoned by the parties thereto, unless it be shown to the satisfaction of the Commissioner of Patents that such delay was unavoidable. 2293

It is contended on behalf of the Commissioner that the question of unavoidable delay is one for the exclusive determination of the Commissioner and his decision is conclusive. The decisions relied on were made in infringement suits where the Commissioner's decision that delay was unavoidable was the subject of collateral attack. On direct appeal from his decision denying renewal, and therefore, substantially rejecting the application, 2294
the situation is very different. While, ordinarily, the exercise of discretion in matters arising in the course of the litigation will not be disturbed unless it has been abused, nevertheless it is subject to review along with other rulings affecting the rights of the parties and will be disturbed where the error in its exercise is plainly shown, and works material hardship and injustice. Kinsman v. Strohm, 31 App. D. C., 581-585. In that case, it is true, the exercise of discretion in reviewing an application was not disturbed, for the reasons given, but the opinion recognizes the power to do so upon sufficient grounds. Section 4894 R. S. 2295
does not, in terms, limit this power of review as was the case in some decisions cited. But it is not necessary to discuss this particular question further. In view of the opinion expressed in Selden's case (36 App. D. C., p. 435), it is admitted by counsel for the Commissioner, that where the question of abandonment is one of law and not of fact, the action of the Commissioner is not conclusive. In this case the facts are specifically

2296 presented in the supporting affidavits. They are clear in their application to every point, and have not been denied. They are, in fact, substantially admitted to be true in both of the decisions heretofore quoted. It appears from the record of proceedings in the office that the objections to the claims of the application were formal and might it is reasonable to believe, have been met by amendment. The substantial ground of rejection was inoperativeness, because it was then seriously doubted, if not generally denied, that aerial flight could be accomplished in heavier than air machines. During the time that has elapsed since
2297 that objection was made the doubt has been removed. As said by the Commissioner: "In the meantime dynamic flight, the age long dream of man, had become an accomplished fact. Others had succeeded in actually flying in heavier than air machines, had obtained patents on their inventions and were reaping the just rewards of their efforts." In view of this statement it is not probable that the objection to operativeness, on the ground urged, would now be permitted to stand. The date of the application, and the description therein demonstrate that the deceased Mattullath was, if not the first, one of the very first
2298 to devise means to accomplish the realization of this "age long dream." That others have, in the meantime, entered the field, obtained patents, and are reaping the rewards of their efforts, is no bar to this earlier application, unless the delay in reviewing the application was avoidable. The Commissioner was in error, we think, in saying that the presumption is conclusive against the existence of acceptable excuse for delay, under the circumstances, on the ground that "to hold otherwise

would be to encourage those who had slept upon 2299
their rights while others struggled on to success, to now enter the field and wrest from them the fruits of their labors." The purpose and policy of the patent law are to give the patent to the first inventor unless he has, by his own fault subordinated his right to a more diligent inventor. The question upon which the right of renewal depended was whether the representatives of Mattullath had "slept upon their rights." The delay in reviewing the application would, in reasonable probability, not have occurred but for the strange action of the office in acting upon some unexplained source
of knowledge of the death of the applicant, and 2300
holding that the death absolutely and at once revoked the power of attorney of his solicitors. The amendments proposed by them, presumably without knowledge of their client's death, were formal; they contained no amplification of the original application and required no additional oath. That the power to make such an amendment had not been revoked by death, and that action could have been taken upon it lawfully, had been declared by the Supreme Court in a decision rendered in January, 1893. De La Vergne Machine Co. *v.* Featherstone, 147 U. S., 209-229. This decision ought to
have been well known in the Office. Strange to 2301
say, that notwithstanding this determination of the revocation of the authority of the solicitors duly entered of record, the order of the former Washington representative of the original solicitors, dated August 14, 1909, to permit a person, having no relation to the interested parties, to inspect the application and drawings, was accepted, filed, and presumably acted upon.

Why the solicitor should have undertaken to

Vol 3

2302 exercise an authority which he knew had been declared revoked, or why, in view of the former order of revocation, he should have been permitted to exercise it are facts that are unexplained, and seem inexplicable on any reasonable ground. Instead of declaring the authority of the solicitors revoked and refusing to recognize them for any purpose, it would have been eminently proper to notify them of the death of their client and suggest the propriety of obtaining a renewal from his legal representatives, meanwhile suspending action for a reasonable time for the purpose. Had this been done, the solicitors would have been under ob-
2303 ligations to inquire for, and notify the intestate's representatives of the situation. They have attempted in the letter of November 20, 1909 to relieve themselves of the moral obligation to give notice by saying that they did not know the address of their client's family. It is contended that notice to the solicitors was the equivalent of notice to the representatives; and that their negligence is to be imputed to petitioner. We do not agree with this. Their negligence in conducting the proceedings, while the relation of client and attorney continued to be recognized in the Office, could be imputed to the applicant. But it is unreasonable to
2304 argue that their neglect was the neglect of the petitioner, when the Office had declared their authority ended. Moreover, they were never the attorneys of the deceased applicant's representatives. Notwithstanding this express revocation, no attempt was made by the Office to notify the widow, which it is said by the Commissioner it was under no obligation to do even if aware of her name and address. Rule 20 is the only Office rule regarding

notice in case of the revocation of a power of attorney, and this the Commissioner held did not require notice to the applicant. The rule, construed literally, does not seem to require notice to the applicant's representatives, but such construction is within its spirit. At any rate, the widow and children of the deceased applicant had no notice, and it clearly appears that they had no knowledge of the pending application, and were in possession of no facts or circumstances sufficient to put them upon inquiry. 2305

Mattullath left no property whatsoever, and his widow, a woman of 62 years of age, was dependent upon one of her children. The family 2306
was without means. Seeking the advice of a friendly attorney—not a patent solicitor—the widow was advised to write to such persons as might be aware of her husband's interests. This was promptly done. The only reply received was from Washington, and gave no information; nor did the writer suggest inquiry at the Patent Office. That he was interested in the subject matter, and doubtless knew that inquiry at the Office might obtain certain knowledge, appears from the fact that he is the same person, who in 1909 obtained the permit to examine the office files in this case.
The attorney, upon whose advice the letter of 2307
inquiry had been addressed, evidently did not know that information might be had at the Patent Office. That she was then acting with diligence and in good faith cannot be denied. All sources of information seeming fully exhausted she remained quiet until stirred into renewed activity by the information of the representative of some other patentee of a flying machine who was engaged in an infringement suit. Probably

2308 his information had been obtained through access obtained to the application file; for it was that person who informed the party of the fact. However that may be, she began in good faith to ascertain her rights. Unable to pay attorney's fees, she procured the services of a charitable attorney who exacted no charge; and managed to raise the sum of forty-one dollars to pay the actual cost of correspondence, copies, etc. The lingering illness of this charitable attorney prevented his filing the petition for renewal. With reasonable diligence she procured the services of another attorney who proceeded with diligence to file the
2309 petition and prosecute the same. It is argued that there was utter failure in the exercise of diligence in that petitioner failed to make inquiry at the Patent Office, because it is a matter of law with knowledge of which she must be charged. It is said in the printed argument: "It is academic that ignorance of the law excuses no one." Without pausing to consider the many exceptions to the rule that ignorance or mistake of law excuses no one, it is sufficient to say that there is no just foundation for the application of the general rule in this case. There is no statutory, or other rule of law requiring parties to apply
2310 for information at the Office. It is a fact that information concerning applications for patents will be furnished to the applicant or his legal representatives or assigns. It is not at all wonderful that a woman like the petitioner should have been ignorant of this fact, especially as it seems not to have been known to the lawyer who advised her where to seek information. Nor is it at all remarkable that she should not have known, in making her inquiries, that there was an essen-

tial difference between an application and a patent. It plainly appears from her sworn statements that she did not know this difference, or that she could obtain information of the application by applying at the Office. It was ignorance of a fact, not of law. 2311

3. The next question is upon the intention of Congress in enacting Section 4894, and the meaning to be given to the word "unavoidable" therein.

In the argument on behalf of the Commissioner it is said: "The decisions of the various Commissioners of Patents upon the meaning to be attached to the words "unavoidable delay" in the Statute have not been always uniform or altogether consistent." As an instance of the extreme view of strict construction he cites the decision of Commissioner Butterworth in ex parte Klenka (28 O. G., 1272; C. D., 39). He declares it a statute of limitation to be enforced with all the rigidity of the old statute of limitations at common law. This construction would render it practically impossible to show any delay that would be unavoidable. On the other hand Commissioner Hall has given the statute a liberal construction. We quote from his opinion in ex parte Pratt (39 O. G., 1549; 1887 C. D., 31): 2312 2313

"The word 'unavoidable,' as used in Section 4894 Revised Statutes, is of very broad significance. In its application to many relations it would exclude every thing but the 'King's enemies' or an Act of God. I do not believe such a construction would be a fair interpretation of the statute. The statute is one regulating a mere practice in the Office, and is not intended to affect substantial rights as between different persons or between persons and the Gov-

2314 ernment. It is rather a provision by which a statutory limitation may be removed. Its purpose is to encourage diligence in proceedings before the Office. If the broad and unlimited meaning of the word unavoidable were to prevail, it is difficult to conceive when an abandoned case could be reinstated under this section. In my opinion, the word is used in a more limited sense. It is applicable to ordinary human affairs, and requires no more or greater care or diligence than is generally used and observed by prudent and careful men in relation to their most important business. It permits them in the exercise of this
2315 care to rely upon the ordinary and trustworthy agencies of mail and telegraph, worthy and reliable employees, and such other means and instrumentalities as are usually employed in such important business. If unexpectedly, or through the unforeseen fault or imperfection of those agencies and instrumentalities, there occurs a failure, it may properly be said to be unavoidable, all the other conditions of good faith and promptness in its ratification being present."

The Commissioner seems to have leaned toward the strictness of the construction first mentioned.
2316 We approve, in general, the doctrine expressed by Commissioner Hall. The first construction is technical, hard and narrow. The second is broad and liberal, breathing the spirit of equity, and more in accord with the general policy of our patent laws. See Smith v. Goodyear Dental Co., 93 U. S., 486-491. Tested by the standard of diligence above declared, we are of the opinion that the delay in this case has been shown to be unavoidable in the proper sense of the statute. The petitioner had not "slept upon her rights," and is entitled to the relief which she seeks. Its denial would work a great hardship, unjustified by her conduct, upon

the penniless widow of a deceased inventor of merit who died almost at the point of success, leaving the invention as his only property. 2317

The decision will be reversed. As heretofore suggested it is improbable that the objection to operativeness will now be insisted upon; but there may be particulars in which the interests of both public and the inventor may be conserved by reasonable amendment. As in the case of Selden, *supra,* the reversal will be with direction to set aside the order of abandonment and reinstate the application. It is so ordered and the Clerk will certify this decision to the Commissioner of Patents. 2318

Reversed.

SETH SHEPARD,
Chief Justice.

(Endorsed.) Patent Appeal Docket No. 751. In the Matter of the Application of Meta Mattullath, Administratrix of Hugo Mattullath. Opinion of the Court per Mr. Chief Justice Shepard. Court of Appeals, District of Columbia, Filed Apr. 1, 1912. Henry W. Hodges, Clerk.

(Seal of Court of Appeals,
District of Columbia.)

(Signed) HENRY W. HODGES,
Clerk of the Court of Appeals 2319
of the District of Columbia.

Defendants' Exhibit "Mattullath Mandate."

U. S. District Court, Western District of N. Y. The Wright Co. *v.* The Herring Curtiss Co. and Glenn H. Curtiss. Defendants' Exhibit "Mattullath Mandate."

GERTRUDE M. STUCKER,
Notary Public.

(Seal of Gertrude M. Stucker,
Notary Public.)

2320 COURT OF APPEALS OF THE DISTRICT OF COLUMBIA,

No. 751 Patent Appeal Docket, April Term, 1912.

In the Matter of the Application

of

Meta Mattullath, Administratrix
of Hugo Mattullath.

Subject Matter: Improvement in flying machines, Serial No. 751.

2321 Appeal from the Commissioner of Patents.

This Cause came on to be heard on the transcript of the record from the Commissioner of Patents, and was argued by Counsel.

On Consideration Whereof, It is now here ordered and adjudged by this Court that the decision of the said Commissioner of Patents in this cause be, and the same is hereby reversed with direction to set aside the order of abandonment and reinstate the application.

per Mr. CHIEF JUSTICE SHEPARD.

April 1, 1912.

2322 A true Copy.

Test:

HENRY W. HODGES,
Clerk of the Court of Appeals
of the District of Columbia.

(Seal of Court of Appeals,
District of Columbia.)

REVUE

DE

L'AÉRONAUTIQUE

THÉORIQUE ET APPLIQUÉE

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6e ANNÉE — 1893 — 4e LIVRAISON

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ﾋ9 REVUE

DE

L'AÉRONAUTIQUE

THÉORIQUE ET APPLIQUÉE

Directeur : Henri HERVÉ

6 ANNÉE — 1893 — 4e LIVRAISON

M. H.-S. MAXIM, ingénieur à Bexley (Angleterre), fera désormais partie du Comité de Rédaction de la *Revue de l'Aéronautique* en remplacement d'un des membres décédés.

En raison du développement considérable des recherches de M. Maxim et des modifications profondes encore apportées par l'inventeur à son œuvre, nous avons cru devoir différer un peu la suite de la publication de ses belles expériences afin d'en éviter le morcellement exagéré et de pouvoir en terminer la seconde partie par l'exposé des formes approximativement définitives auxquelles l'auteur se sera rallié (*).

L'AÉROPLANE « ÉOLE »

Par M. C. ADER

Dans la série des grandes constructions et des expériences aéronautiques importantes dont nous poursuivons ici la publication intégrale, nous ne pouvions oublier de réserver une place aux intéressantes recherches de M. C. Ader, l'ingénieux inventeur d'un téléphone très répandu et qui a consacré de longues années et des sommes considérables à ses études sur la locomotion aérienne au moyen de sustentateurs mécaniques.

M. Ader, qui s'occupe activement à l'heure actuelle d'apporter à ses appareils de nombreux perfectionnements, fit ses premiers essais en grand et entièrement à ses frais à la fin de l'année

(*) On a dit que la machine motrice des aéroplanes Maxim consommait tant de vapeur que les avantages de l'énorme allégement du système en étaient annihilés.

Or M. Maxim a vérifié maintes fois que la condensation de la vapeur est à peu près complète dans les essais sur l'aire, et l'extrême *perméabilité thermique* de l'aéro-condenseur autorise formellement à admettre que cette propriété persisterait dans les conditions normales du vol.

En admettant donc, comme on l'a prétendu inexactement, que cette consommation atteignit 25 kg. de vapeur par cheval, la déperdition porterait non à la fois sur le liquide évaporatoire, élément principal, et sur le calorique, c'est-à-dire sur le combustible, mais seulement sur ce dernier. H.

1890. M[me] Isaac Pereire, par l'entremise de son fils M. Gustave Pereire, autorisa l'inventeur à établir dans le vaste parc du château qu'elle possède à Armainvilliers près de Gretz, les aires de manœuvre indispensables.

Le 9 octobre, à 4 heures du soir, l'aéroplane *Eole,* de 15 mètres environ d'envergure, actionné par un moteur à vapeur de 18 à 20 chevaux de force, et monté par M. Ader, *perdait complètement terre* en rasant le sol. Par malheur la stabilité insuffisante de l'appareil ne permit pas de poursuivre sans témérité cette tentative dont le résultat, quoique nullement négligeable, indiquait la nécessité de nouvelles études.

M. Ader est, en aéronautique, un adepte fervent de l'imitation rigoureuse de la nature; il ne s'en écarte jamais sans un vif regret. On verra, par la description des surfaces sustentatrices, qu'aucune complication de mécanisme ne rebute sa patience ni n'altère sa robuste conviction. Notre manière de voir personnelle est trop différente de celle de l'auteur pour que nous ne nous bornions pas ici à cette simple constatation. D'ailleurs si diverses parties de son œuvre semblent appeler plus particulièrement la critique, comme le mode d'établissement des surfaces sustentatrices, fragiles par leur mobilité générale, la position saillante et orthogonale du condenseur, cause de résistances parasites considérables, etc., il ne faut pas moins observer que l'auteur a dû, pour réaliser son projet, surmonter des difficultés de construction extrêmement ardues et lui rendre un hommage mérité.

Regrettons seulement, pour la *Revue,* que M. Ader se soit borné à un exposé purement descriptif et ait jugé prématuré de nous fournir les données numériques que nous eussions souhaité présenter à nos lecteurs.

∴

L'auteur emploie le mot *avion* (de *avis*, oiseau) pour désigner son appareil ailé; nous avons cru devoir cependant conserver à celui-ci le nom d'aéroplane. Comme tout aéroplane, en effet, l'appareil de M. Ader possède un propulseur indépendant du sustentateur *fixe*. Au contraire les oiseaux mécaniques, auxquels conviendrait plutôt le vocable *avion*, sont caractérisés par la réunion, dans leurs ailes *battantes*, des deux fonctions : sustentatrice et propulsive.

Sans doute les surfaces sustentatrices de l'appareil Ader, ne sont pas absolument fixes, mais leur mobilité relative et temporaire ne détermine pas la propulsion, elle la modifie seulement. Le mouvement propulseur y est circulaire continu; il est, au contraire, alternatif chez l'oiseau naturel ou artificiel.

Le caractère qui différencie le plus l'aéroplane Ader des aéroplanes antérieurs de Penaud ou de Maxim, par exemple, consiste en ce que M. Ader cherche à obtenir, principalement à l'aide de variations de formes et de position des *surfaces sustentatrices* proprement dites, les résultats que la plupart des autres expérimentateurs demandent spécialement à l'action de *surfaces auxiliaires* distinctes, automatiques ou non.

Cette divergence ne nous a paru ainsi porter que sur un point secondaire et nous a semblé insuffisante pour justifier l'emploi d'une expression nouvelle destinée à caractériser un genre de volateurs artificiels qui ne fussent ni oiseaux mécaniques, ni aéroplanes. H.

AVANT-PROPOS

Le vol des oiseaux et des insectes m'a toujours préoccupé. Pendant ma jeunesse, l'idée m'étant venue de faire un coléoptère mécanique volant, je me mis aussitôt à l'œuvre.

Ce petit appareil avait deux ailes creuses fixes, horizontales, façonnées avec de l'osier et du papier; sur le devant une hélice faite aussi avec de l'osier et du papier remplaçait les ailes de l'insecte vivant; de plus, l'appareil fut muni d'une queue (fig. 24).

Un ressort et des engrenages faisaient tourner l'hélice, et un petit tube en partie rempli de mercure, était destiné à faire baisser ou remonter la queue selon que l'appareil inclinait en avant ou en arrière. Mais à mon grand désespoir j'avais beau tendre le ressort et graisser les engrenages, l'appareil retombait toujours à terre. Je recommençai avec d'autant plus de persévérance que les petits résultats obtenus étaient appréciables. Je parvins assez bien à faire voler à quelques mètres de distance des petits appareils, mais plus je les faisais grands, plus cela devenait difficile et au-dessus d'une certaine dimension la difficulté croissait d'une façon désespérante. J'avais essayé tous les genres d'ailes d'oiseaux, de chauves-souris et d'insectes, disposées en ailes battantes, ou ailes fixes avec hélice, et j'avais imaginé des moteurs pour chaque cas. Alors seulement je pus sonder la profondeur de toutes les difficultés à vaincre et entrevoir la distance effrayante qui sépare l'idée première de la réalisation du problème. Complétant expérimentalement ma première théorie sur les surfaces planes et courbes en mouvement

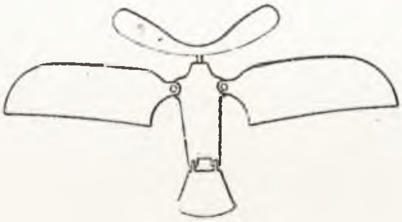


Fig. 24.

dans l'air et les résistances qu'elles y rencontrent, je découvris l'importante courbe universelle du vol ou de sustentation. Je terminai sur place l'étude du vol des grands oiseaux, les cigognes à Strasbourg, les vautours en Algérie, à Constantine. Dans mon laboratoire je fis voler des roussettes de l'Inde et demandai à l'anatomie le secret de la construction des charpentes des volateurs. Enfin après avoir exécuté quelques-uns de mes projets d'appareils volants, j'entrepris de 1882 à 1890, la construction de l' « *Éole* » qui fut expérimenté le 9 octobre de cette dernière année et auquel se rapporte la description qui va suivre.

Les appareils ailés futurs pour la réalisation de la navigation aérienne ne battront pas des ailes; pour voler ils planeront continuellement. Leurs ailes creuses les supporteront et un propulseur placé à l'avant les fera avancer et entretiendra la vitesse. La force motrice sera fournie par la vapeur appropriée à cet usage particulier.

Ils seront toujours essentiellement composés :

1° Du corps; 2° des ailes; 3° de la force motrice; 4° du propulseur.

Sans l'une de ces parties l'aéroplane ne pourrait exister. Nous allons les décrire en ordre et énumérer les principes nouveaux qui leur sont appliqués.

CHAPITRE PREMIER

CORPS DE L'AÉROPLANE

Le corps de l'aéroplane est charpenté de manière à supporter les organes qu'il contient, à être supporté lui-même par les ailes pendant le vol et à sup-

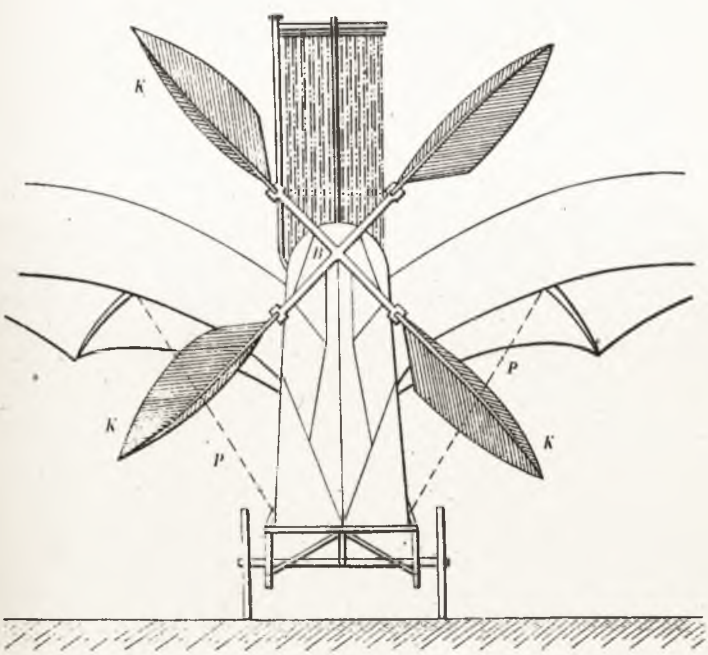


Fig. 25.

porter à son tour tout l'ensemble à terre. Les planches XII à XV et la fig. 25 en donnent les lignes principales. On peut désigner ses diverses parties :

Épaule, la grande charnière où s'articulent les ailes;

Bec, son extrême avant qui porte le propulseur;

Cou, l'endroit où est placée la machine;

Dos, le dessus qui reçoit le condenseur et laisse passer la cheminée;

Intérieur, la place du générateur;

Flancs, la partie qui porte les réservoirs de combustible;

Pieds, composés de roues, ou de patins (à surface intermédiaire glissante, suspendus avec des ressorts), dont deux latéralement, une autre à l'avant et une quatrième à l'arrière pour diriger l'aéroplane sur l'aire.

L'aviateur est placé à l'arrière en V (Pl. XII). Les appareils de manœuvre sont à sa portée. Quand l'aéroplane a un gouvernail vertical, celui-ci est solidaire de la roue d'arrière et manœuvré avec elle. Le corps de l'appareil est recouvert d'un bout à l'autre par une enveloppe imperméable.

CHAPITRE SECOND

AILES SUSTENTATRICES

I. — COURBE UNIVERSELLE

Quel que soit le genre des ailes, elles sont essentiellement cintrées de l'avant à l'arrière, par rapport à la direction de la translation, suivant une

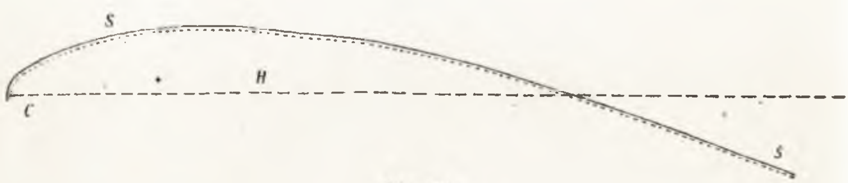


Fig. 26.

courbe particulière qui se trouve être une spirale (fig. 26 et 27). On sait que le caractère de la spirale est de tourner autour d'un centre en s'en éloi-

Fig. 27.

gnant toujours, et que toutes les tangentes à n'importe quel point de la courbe forment avec le rayon des angles semblables; on peut ainsi tracer des spirales plus ou moins cintrées.

Cette courbe est indispensable à une surface en translation pour lui permettre de trouver le maximum d'appui dans l'air. Elle est également applicable et indispensable aux plumes isolées et aux ailettes des propulseurs.

On peut l'appeler *courbe universelle de sustentation* du vol et d'appui dans l'air.

Le cintrage, ou degré de courbure de la concavité des ailes, changera selon les vitesses et les charges, mais sans jamais perdre le caractère de spirale. Pour toutes les ailes sans exception, grandes et petites, le point C central, ou de départ, de la courbe spirale coïncide avec l'avant de l'aile, les figures 26 et 27, représentant deux spirales S absolument semblables, en donnent un exemple. Sur celle de la figure 26 on voit un trait plein qui montre la forme d'une grande aile; sur la figure 27 le trait plein représente une autre aile, bien plus petite. Les lignes horizontales H indiquent la direction de la translation. Une même aile pourra changer son degré de cintrage pendant le vol, mais ce ne sera qu'une modification de la spirale.

II. — LOIS COMMUNES A TOUTES LES AILES

Toutes les ailes, de quelque forme et de quelque nature qu'elles soient, devront obéir aux mêmes lois. Il ne peut en être autrement parce que les difficultés de la locomotion dans l'atmosphère, surtout quand celle-ci est agitée, et les évolutions du départ ou de l'atterrissage sur l'aire seront les mêmes pour tous les appareils aériens. Les aéroplanes auront aussi inévitablement dans leur poids de grandes différences produites par la consommation de combustible, ou par des allègements s'ils laissent tomber à terre une partie de leur charge.

De tout cela, naît la nécessité de pouvoir orienter, ralentir ou accélérer la vitesse de translation. Et pour pouvoir y arriver, il faut que les ailes soient susceptibles de faire pendant le vol quatre mouvements principaux :

important 1° Se porter en entier vers l'avant ou vers l'arrière;

2° Se plier sur elles-mêmes pour diminuer ou étendre leur surface;

3° Se gauchir;

4° Cintrer à volonté la courbe universelle.

aussi Toutes les combinaisons des charpentes, des articulations, des nerfs et des membranes, sont faites dans ce but.

A cause des grandes difficultés qui accompagnent la question de la vitesse, nous avons été obligés de faire des ailes pour des appareils à petite et à grande vitesse.

III. — AILES POUR PETITES VITESSES

Elles sont du genre chauve-souris (Pl. XIV, fig. 1). Leur charpente se compose d'un bras B en forme d'S; d'un avant-bras AB courbé en avant en même temps qu'en dessous; d'une main M qui porte le pouce et quatre doigts D_1, D_2, D_3, D_4, ayant des phalanges; ces doigts et ces phalanges ont des courbures appropriées à la forme de l'aile.

Toutes les pièces des charpentes sont articulées de manière qu'on puisse leur faire prendre les positions nécessaires pour le vol. Le bras se plie contre le corps, l'avant-bras se plie sur le bras et les doigts se plient contre l'avant-bras; les pattes E suivent ces mouvements à cause de la bielle L. C'est ce pliage ou cette manœuvre qui doit augmenter ou diminuer la surface des ailes.

En outre, les phalanges des doigts peuvent s'abaisser ou se relever verti-

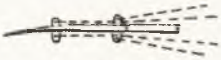


Fig. 28.

calement; il en est de même pour les pattes. Cette opération qui est destinée à augmenter ou à diminuer le cintrage de la courbe universelle est montrée sur la figure 28.

A part cela le coude U tourne sur lui-même et par suite entraîne l'avant-bras, la main et ses doigts. Cette opération est destinée à gauchir le bout de l'aile afin de rompre ou de rétablir l'équilibre dans les ailes.

Il y a un autre mouvement général qui consiste à porter toute l'aile en avant ou en arrière en la faisant pivoter sur son articulation de l'épaule.

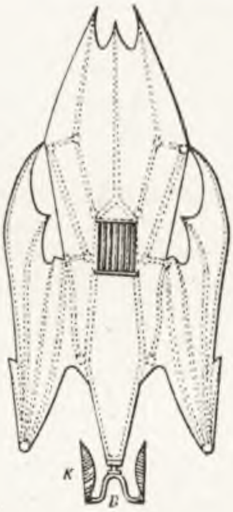


Fig. 29.

Cette opération capitale a pour but de mettre en équilibre tous les centres d'action de l'air sur les ailes avec le centre de gravité de l'aéroplane. Ces manœuvres sont faites de l'intérieur du corps, en plein vol, à l'aide de nerfs.

Les intervalles entre les membres sont garnis de membranes. Il y a des membranes entre les doigts; à l'avant se trouve une membrane d'angle V. retenue par le bras et l'avant-bras; une grande membrane tient au quatrième doigt, à l'avant-bras, au bras, au corps et aux pattes; enfin une membrane de queue (Pl. XIV).

Les membranes sont traversées par des lignes de force F, ou tirants; leurs directions sont courbes; la forme arquée que l'on voit à l'arrière des membranes est la conséquence finale des courbures de ces lignes de force. Dans certaines parties de l'aile ces lignes de force peuvent être rigides; alors là les membranes conservent la même surface; mais leur caractère essentiel est d'être élastiques, afin que, quand les membres se plient, les membranes restent toujours tendues. Cela, on le comprend, vient aider l'opération de l'augmentation ou de la réduction de la surface des ailes.

Au repos, à terre, les ailes se plient complètement. Cette faculté permet de les soustraire à l'action du vent et de les remiser plus facilement comme on le voit figure 29.

Les membranes sont tendues par des nerfs antagonistes placés à l'avant sur les doigts et dont on peut graduer le tirage à volonté.

A l'arrière ce sont les pattes qui font la résistance.

IV. — AILES POUR GRANDES VITESSES

Elles sont du genre oiseau comme charpente, avec des membranes dans les intervalles (Pl. XIII, fig. 1). Leur charpente consiste en un bras B en forme d'S, et un avant-bras AB à deux pièces. La pièce principale est courbée en arrière; l'autre suit la courbure de celle-ci, moins cependant près du coude; toutes les deux sont également courbées en dessous. A l'extrémité de l'avant-bras se trouve la main M.

Ainsi que cela a été expliqué pour l'aile à petite vitesse, tous ces membres se plient aussi pour obtenir les différentes positions qu'exige l'action du vol.

La membrane d'angle V, entre le bras et l'avant-bras, est semblable à celle des ailes à petite vitesse, elle est cependant un peu plus étroite.

Les membres de l'aile portent des tiges T qui sont essentiellement courbées dans le sens horizontal aussi bien que dans le sens vertical. Elles tiennent aux membres par des articulations et des nerfs qui leur sont propres; elles peuvent se plier en même temps que les membres de l'aile et suivre les mouvements de ceux-ci. Ces tiges ont surtout la faculté de pouvoir tourner sur elles-mêmes toutes en même temps et, étant donnée leur forme longitudinale courbe, on peut, à l'aide de ces mouvements giratoires, donner à la courbe universelle le degré de cintrage que l'on désire. Les intervalles entre les tiges sont garnis de membranes élastiques et par conséquent toujours tendues.

La queue est faite avec des tiges comme celles des ailes et de plus elle peut avoir en dessous, et même en dessus, un gouvernail vertical Z que l'on voit sur la planche XII. Ces deux gouvernails sont manœuvrés de l'intérieur.

V. — DÉTAILS DES CHARPENTES ET DES NERFS DES AILES

Voici d'abord ceux des *ailes à petite vitesse :*

L'aile dans son ensemble est retenue par un nerf pectoral P, articulé dans le prolongement de l'articulation de l'épaule, fixé en bas sur les flancs du corps de l'aéroplane et en haut au bras de l'aile (fig. 25).

L'avant-bras AB tient au bras B par le coude (fig. 30 et Pl. XIV, fig. 1);

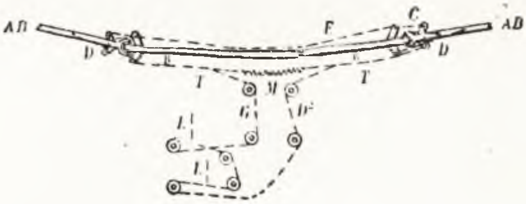


Fig. 30.

un nerf C le tient relevé et un autre nerf D le tient baissé et supporte l'effort pendant l'action du vol. L'avant-bras tourne sur lui-même, au coude, à l'aide du nerf moufflé T. Les nerfs T de gauche et celui de droite sont reliés ensemble afin qu'ils se fassent compensation; pour éviter la rudesse des efforts brusques ils ont un muscle auxiliaire M dans leur parcours. Ces nerfs sont sollicités par d'autres nerfs G et D² venant de l'intérieur et mus par des pédales L, ou autres organes.

Par-dessus les coudes il y a un autre nerf E, qui fait des mouvements semblables. Ainsi donc, quand un avant-bras tourne dans un sens, l'autre tourne dans le sens opposé.

L'avant-bras se ferme ou s'ouvre horizontalement sur le bras à l'aide des nerfs P² et D³ (fig. 31) que l'on manœuvre de l'intérieur.

Fig. 31.

Les doigts sont articulés à la main et y sont tenus relevés par des nerfs; d'autres nerfs en dessous les maintiennent baissés et supportent les efforts pendant l'action du vol; ces nerfs sont à peu près comme ceux C et D de la figure 30. Dans le sens horizontal ils sont tirés fortement en avant par les nerfs H et P (Pl. XIV et fig. 31) pour tendre les membranes. Ces nerfs sont, à l'origine, attachés au bras B, de sorte que plus l'avant-bras AB s'ouvre, plus les doigts sont tirés en avant et tendent la membrane; à l'arrière le nerf N est fixé au bras sur l'ergot.

A l'inspection de la figure on voit que, par l'opération du pliage de l'avant-bras sur le bras qui se fait de l'intérieur, on plie aussi les doigts et par suite on détend la membrane ou on la tend, on diminue ou on augmente la surface de l'aile. En outre, quand il faut opérer une forte tension, on relève le pouce par un nerf mouflé R (fig. 32), et comme le nerf P est rigide et fixé à l'épaule

Fig. 32.

il entraîne en avant le premier et le deuxième doigts et tend fortement les membranes.

La figure 33 montre en diagramme une disposition des nerfs pour la manœuvre des phalanges des doigts et des pattes. Ces nerfs sont actionnés par des leviers L par exemple; tout est en parfait équilibre. Pendant le vol,

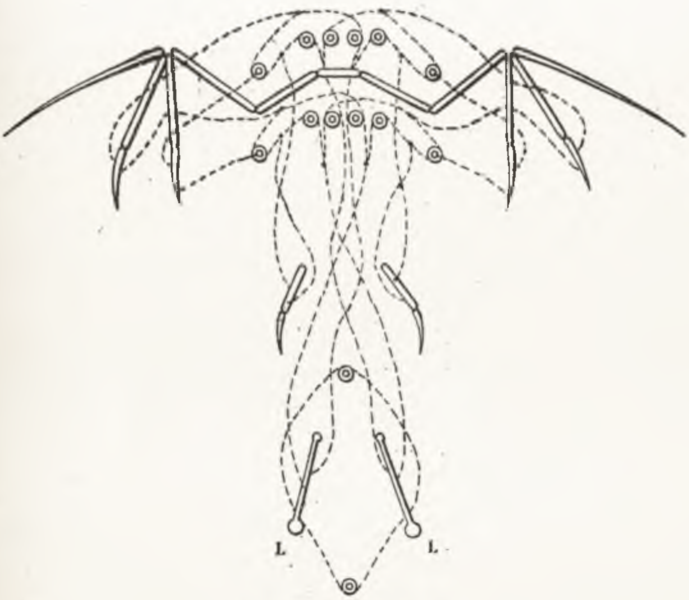


Fig. 33.

l'action de l'air sous les ailes y trouve sa résistance; mais si l'on actionne l'un ou l'autre des leviers séparément, ainsi qu'on le voit en suivant la direction des nerfs, l'équilibre est rompu et la résistance à l'air change de place par le fait du changement d'inclinaison des phalanges; si on abaisse les deux leviers en même temps l'équilibre n'est pas rompu, mais toutes les phalanges se baissent et il y a accentuation dans le cintrage de la spirale ou courbe universelle du vol. Dans ce diagramme il n'y a de représentés que les nerfs d'une phalange par doigt; on comprend qu'il en est de même pour les autres phalanges. On peut d'ailleurs faire varier ces combinaisons pour manœuvrer les phalanges séparément.

Pour tenir l'avant-bras tendu et ouvert (Pl. XIV, fig. 1) il y a le long de la bielle L, un nerf B' amarré au genou et au bras; ce nerf concourt à ouvrir l'avant-bras et aide le nerf D^3 que nous avons vu sur la figure 31.

Les jambes des pattes sont fortement tirées par des nerfs X que l'on voit sur la planche XIV. Un mouvement en avant tire la jambe en avant et inversement un mouvement en arrière oblige les jambes à en faire autant, cette disposition est nécessaire pour le tirage régulier des pattes sur la grande membrane.

Pour porter les ailes entières en avant ou en arrière on arrange les nerfs comme à la planche XIV. En tirant le nerf C on porte l'aile en avant, en tirant le nerf B^2 on l'amène en arrière; de même avec les nerfs A' et R' qui sont des nerfs de sûreté. La commande de ces nerfs se fait de l'intérieur par des treuils ou autres organes.

Les détails des *ailes à grande vitesse* diffèrent un peu des précédents, ainsi qu'on le voit sur la portion de charpente représentée fig. 34. L'avant-

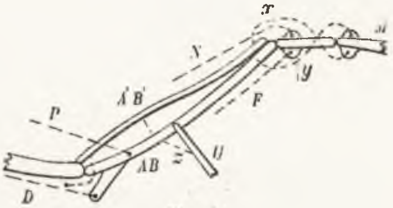


Fig. 34.

bras est composé de deux pièces : celle d'avant A'B' plus faible que la principale AB; elles s'articulent toutes deux sur le bras B dont on voit une partie; la main M s'articule sur l'avant-bras; cette main est en deux pièces et sa partie extrême M' est articulée.

Les nerfs P et D font ouvrir et fermer l'avant-bras sur le bras; indépendamment de ceux-ci il y en a d'autres en dessous, non indiqués sur la figure, et destinés au mouvement de l'avant-bras sur lui-même comme pour les ailes à petite vitesse (fig. 30).

Le petit nerf *S* fait manœuvrer la pièce d'avant de l'avant-bras et il en est de même en dessous; les nerfs N et F tirent sur la main, ils sont représentés coupés sur la figure, mais ils sont amarrés au coude, sur le bras, respectivement devant et derrière, de sorte que le pliage de l'avant-bras entraîne aussi le pliage de la main, comme il a été expliqué pour l'aile à petite vitesse; ces nerfs sont corrigés dans ce mouvement automatique par d'autres nerfs mus à volonté de l'intérieur.

L'extrémité de la main M est solidaire du pliage de la main entière, à l'aide des nerfs x et y; ce pliage a lieu dans le même sens. La main est retenue soulevée ou baissée par d'autres nerfs indépendants, dont deux principaux, l'un sur la pièce de la main M, l'autre en arrière sur un ergot T appartenant à la pièce de la main (fig. 35). Il en est de même en dessous

Fig. 35.

depuis le bras jusqu'à la main; en dessous de l'avant-bras AB, il existe un gros nerf T' que l'on voit sur la figure 36.

Les tiges des porte-membranes ou des plumes U sont articulées sur la pièce principale AB (fig. 34). Ces tiges ont des tirants ou petits nerfs z, en dessous, qui passent sous le nerf T' de la figure 36, et vont s'amarrer sur la

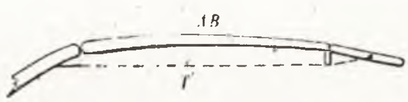


Fig. 36.

pièce d'avant de l'avant-bras AB', de sorte que plus le nerf se tend, plus il tend celui des tiges. On voit mieux ce montage sur la figure 37 où on remarque en coupe les trois points nécessaires à l'amarrage des tiges : d'abord la

Fig. 37.

grosse pièce de l'avant-bras qui sert de butée à la tige; puis la petite pièce d'avant qui sert d'amarre au petit nerf de la tige; enfin le gros nerf du dessous de l'avant-bras qui la maintient baissée.

Quant aux directions des axes et aux nombreux détails des articulations, leur complexité en rendrait toute description difficile.

VI. — MODE DE CONSTRUCTION DES ARTICULATIONS, CHARPENTES, NERFS, ETC.

Les pièces des charpentes sont creuses, faites avec des fibres de bois et de bambou, ajoutées en biseau. Parfois elles sont garnies intérieurement de moelle de sureau, de liège ou de mastic léger. Quand les pièces ont à supporter de la torsion on donne aux fibres une direction hélicoïdale. Plus tard on pourra les faire en métal.

Les nerfs ou tirants fixes sont en fibre de bambou ou d'autre bois.

Les œils, chapes, rotules, axes, ergots, glissoirs, etc., qui composent les articulations sont obtenus avec les pièces mêmes en pliant et contournant les fibres qui les composent. Il en est de même pour les amarres des tirants ou attaches de nerfs.

Pour fixer ces divers matériaux on se sert de toiles, fibres, feutres, ligaments, de gélatines ou de colles imperméables.

Les nerfs du mouvement glissent ou tournent autour des poulies; ils sont en corde de soie ou de boyau, ou en fils métalliques.

Les membranes sont en soie imperméabilisée et recouvrent tout le dessus de l'appareil. L'élasticité de leur ligne de force est obtenue par de petits ressorts métalliques ou par des élastiques en caoutchouc très rapprochés et logés dans des fourreaux.

VII — VARIATION DANS LA FORME DES AILES

L'aile pour les grandes vitesses pourrait être en tout point semblable à celle des oiseaux en mettant des plumes artificielles à la place des membranes qui sont entre les tiges. On trouvera la description des plumes artifi-

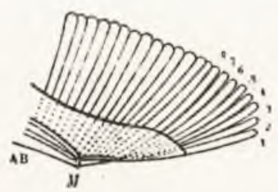


Fig. 38.

cielles au chapitre qui concerne le propulseur. La figure 38 montre ces ailes : les plumes des bouts de l'aile sont relevées par l'action du vent; la première est celle qui l'est le plus, la seconde l'est moins, la troisième moins encore

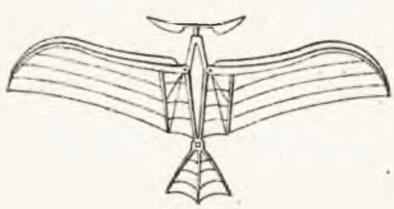


Fig. 39.

et ainsi de suite jusqu'à la huitième qui est dans le rang. Malheureusement la confection de ces plumes est extrêmement coûteuse.

Pour simplifier une aile du genre chauve-souris on pourrait supprimer tout ou une partie de l'élasticité de la membrane et aussi paralyser les mouvements de certains membres, en ne conservant que la courbe universelle fixe et le pivotage horizontal des ailes à l'épaule, qui sont indispensables. Toutefois avec une aile semblable on peut bien se maintenir dans l'air, mais seulement dans des conditions favorables de l'atmosphère.

On peut pousser la simplification plus loin en faisant les ailes comme

Fig. 40.

celles de la figure 39, et davantage encore comme à la figure 40. Enfin, l'extrême limite est représentée par la figure 41.

En résumé les formes rationnelles des ailes à petite et à grande vitesse,

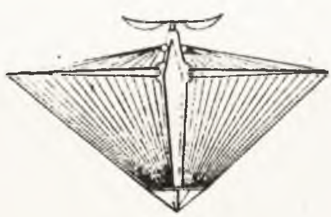


Fig. 41.

décrites plus haut, sont celles qui conviennent le mieux aux aéroplanes destinés à voler en tout temps et quel que soit l'état de l'atmosphère.

Il a fallu emprunter ces deux grands types à la nature, ainsi que les principes; impossible de faire autrement, nous estimant très heureux, non pas de les atteindre, mais de les approcher un peu. Nous n'avons pas parlé des moyens et considérations théoriques qui ont servi à établir les formes et dimensions exactes des charpentes et des membranes, car ils sont extrêmement compliqués et l'exposé en serait trop long.

RÉSUMÉ

Ainsi, en ce qui concerne les ailes de l'aéroplane, les principes et moyens essentiels employés par nous, sont notamment :

Courbe universelle de sustentation appliquée aux ailes et à leur propulseur indépendant.

Mobilité des ailes à l'articulation de l'épaule dans le sens horizontal, ce qui permet, pendant le vol, de les porter vers l'avant ou vers l'arrière pour mettre en équilibre les centres d'action de l'air sur les surfaces avec le centre de gravité de l'aéroplane.

Pliage partiel sur eux-mêmes des membres des ailes pendant le vol, afin de diminuer ou augmenter leur surface, selon les nécessités des vitesses ou des évolutions.

1744

Mouvement tournant de l'avant-bras autour du coude ou de toute autre partie de l'aile pour la gauchir.

Mouvement vertical des phalanges des doigts, pour les ailes genre chauve-souris, et mouvement giratoire des tiges porte-membrane pour les ailes genre oiseau, afin de faire varier à volonté, pendant le vol, le degré de cintrage de la courbe universelle de sustentation sous les ailes.

Élasticité des membranes qui relient les membres ou les tiges, de telle sorte que leur surface soit toujours tendue quel que soit le degré du pliage.

Courbure des lignes de force ou tirants qui sillonnent les membranes, que ces lignes de force soient élastiques ou non.

Pliage complet des ailes à terre pour les soustraire à l'action du vent et réduire le volume des aéroplanes.

Variété des ailes.

Roue d'arrière, dirigée avec le gouvernail vertical pour l'atterrissage.

CHAPITRE TROISIÈME

FORCE MOTRICE DE L'AÉROPLANE

La force motrice est produite par un ensemble d'appareils comprenant un générateur de vapeur avec son foyer, une machine, un condenseur de vapeur, et divers accessoires. Nous ne décrirons que ce qui présente un caractère de nouveauté.

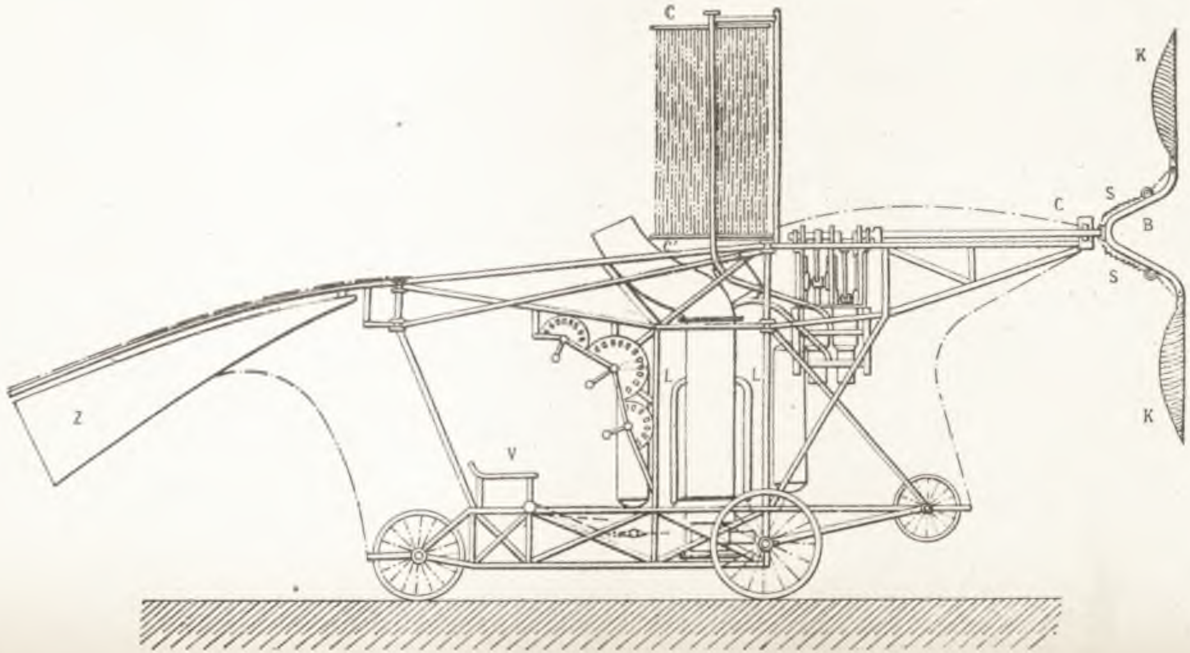
I. — GÉNÉRATEUR DE VAPEUR

(A) PREMIER MODÈLE

Les générateurs de vapeur (Pl. XV et fig. 42) sont à plusieurs séries d'éléments. Chaque série se compose d'une rangée de petits tubes ou éléments vaporisateurs P, droits en bas, ondulés en haut, et aboutissant aux deux extrémités à des petits collecteurs C. Les séries sont disposées parallèlement et sont raccordées en bas et en haut à d'autres collecteurs D plus grands qui sont disposés latéralement et communiquent, par les tuyaux D, avec un réservoir commun R, où la vapeur se sépare de l'eau. Après avoir traversé la machine, la vapeur se rend au condenseur, s'y liquéfie et revient en cet état dans le bas du générateur.

Entre les séries est ménagé un espace pour la circulation des gaz chauds de la combustion. Ces générateurs sont donc chauffés par tranches, de bas en haut, chaque tranche ou série se comportant comme un générateur particulier. En cas d'avarie, chaque série ou chaque groupe de séries peut être isolé à l'aide de robinets ou de soupapes automatiques.

La position du générateur dans le corps de l'aéroplane est au centre, avec cheminée inclinée à l'arrière.



Aéroplane. — Coupe verticale longitudinale. — *(Échelle : 31mm par mètre.)*

(Propulseur en projection diagonale.)

– None ever built like this – too much –
– No margins to dif. angles incidence –
– No warping – only change curvature of wing,
affecting lifting –
– Decipherable – 1. Backward & forward movement wings like birds.
2. Spread fingers or phalanges to change area – duck's foot – tips of wings, not affecting incidence
3. Possibly fingers movable up & down
4. Changes curvature wings.

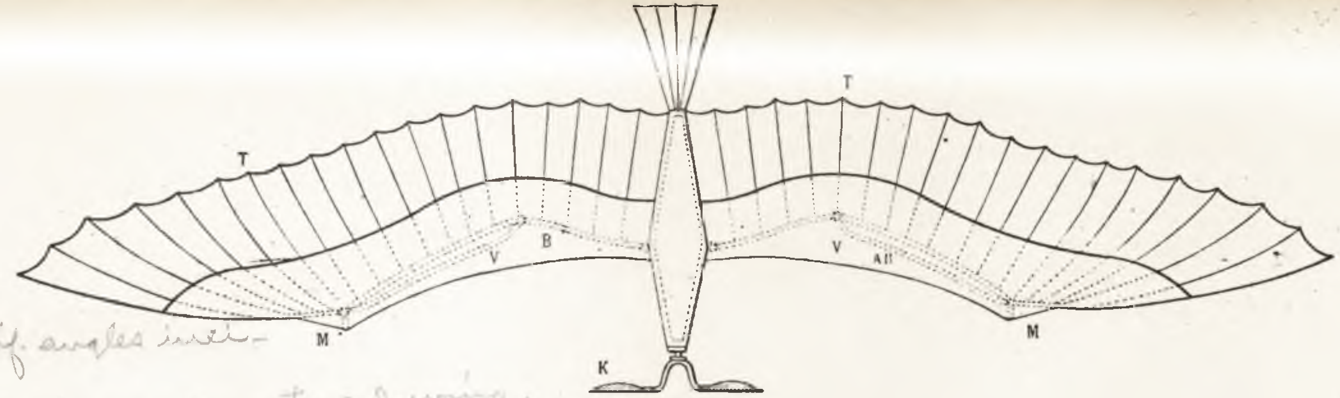
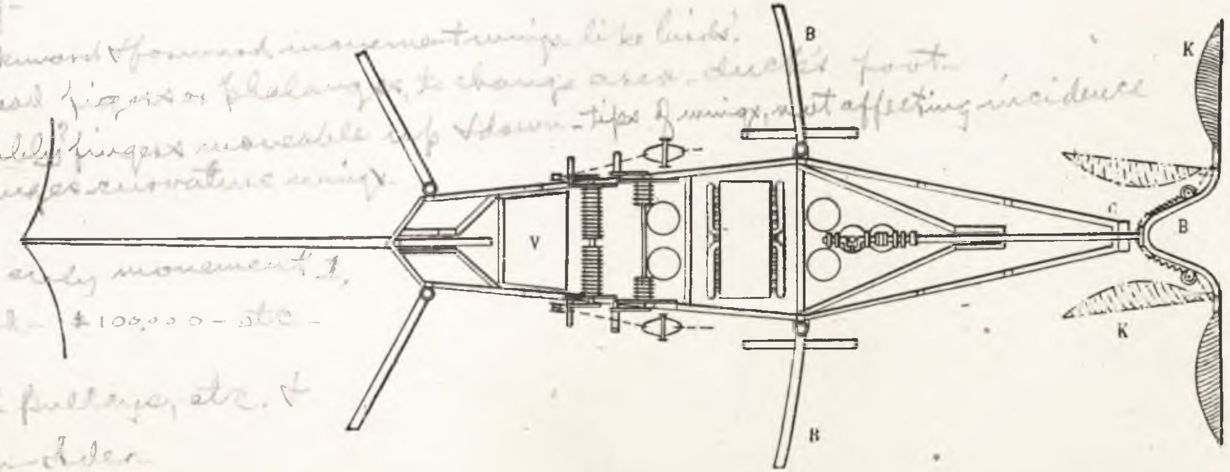


Fig. 1. — Surfaces sustentatrices. — Ailes pour grandes vitesses.



– Mach. tried, having only movement 1.
Never left ground – $100,000 – etc –

– G. a. d. dis. changed pulleys, etc. & made out a glider

Fig. 2. — Corps de l'aéroplane et propulseur. — Coupe horizontale longitudinale. — *(Échelle : 31mm par mètre.)*

(Propulseur en projection diagonale.)

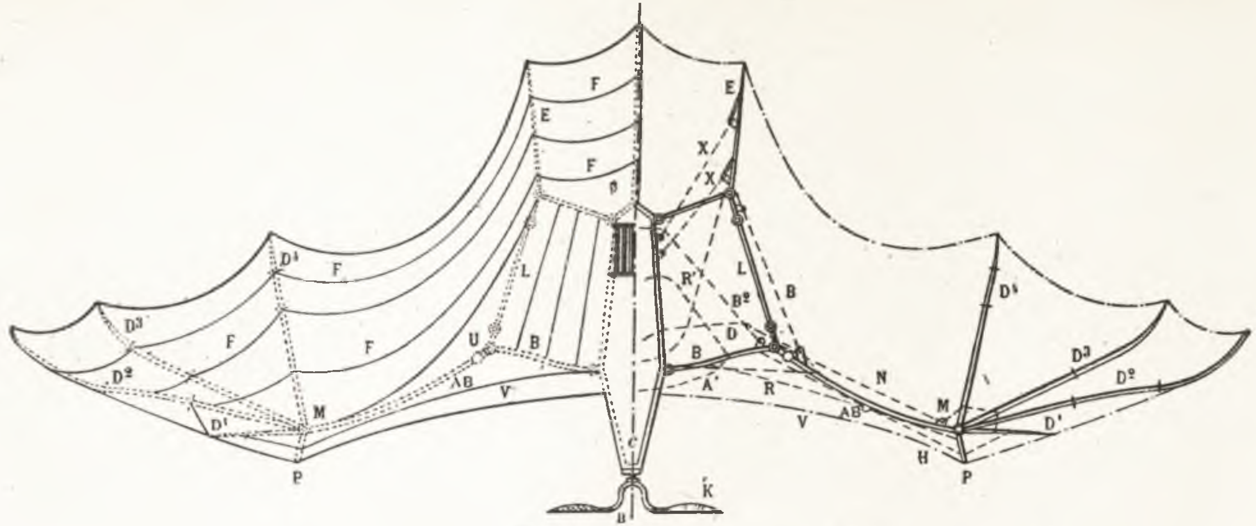


Fig. 1. — Surfaces sustentatrices. — Ailes pour petites vitesses. — *(Échelle : 12mm 4, par mètre.)*

(Propulseur en projection diagonale comme ci-dessous.)

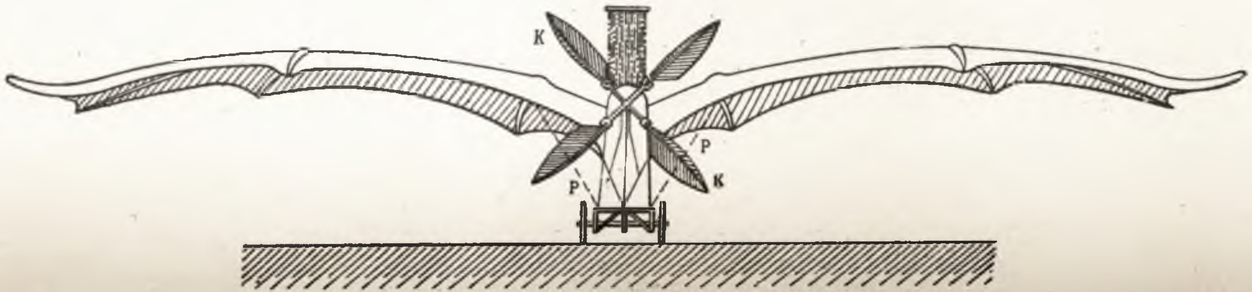


Fig. 2. — Aéroplane. — Élévation de face. — *(Échelle : 12mm 4, par mètre.)*

2380 **Defendant's Exhibit "L'Aeronautique Translation.**

Mr. H. S. Maxim, engineer of Bexby (England), will hereafter form a part of the Editorial Committe of the Revue de l'Aeronautique, taking the place of one of the members deceased.

In consequence of the substantial development of the investigations of Mr. Maxim, and of important modifications made by the inventor in his work we have thought we should defer a little the continuation of the publication of his beautiful experiments, in order to avoid exaggerated parcelling out of it, and to be able to end the second part, by
2381 setting forth the approximately definite forms which the author shall have adopted. (x)

(x) It is said that the driving engine of the Maxim aeroplanes consumed so much steam that the advantages of the enormous lightening of the system were annihilated.

Now, Mr. Maxim has proved many times that the condensation of the steam is almost complete in the trials upon the testing ground, and the extreme thermic permeability of the aero-condenser allows of formally admitting that this property would persist under the normal conditions of flight.

2382 Admitting then, as has been incorrectly pretended that this consumption reaches 25 kilos of steam per horsepower the waste would not effect at the same time the evaporating liquid, the principal element, and upon the caloric, that is to say, upon the fuel, but only upon this latter.

The Aeroplane Eole, by Mr. C. Ader.

In the series of large constructions and of important aeronautical experiments, the entire publication of which we carry on here, we could not forget to reserve a place for the interesting investigations of Mr. C. Ader, the ingenious inventor of a telephone very widely used, and who has devoted long years and considerable sums of money to his studies of aerial locomotion by means of mechanical sustaining devices. 2383

Mr. Ader, who at the present time, is actively employed in adapting numerous improvements to his apparatus, made his first experiments on a large scale and entirely at his own expense at the end of the year 1890. Madame Isaac Percire, authorized through the intermediation of her son, Mr. Gustave Percire, the inventor to establish in the vast park of the castle which she owns at Armainvilliers, near to Gretz, the areas indispensable 2384
for manœuvering.

On the 9th of October, at 4 o'clock in the evening, the aeroplane Eole, of about 15 meters spread, operated by a steam engine of from 18 to 20 horse-power and mounted by Mr. Ader, complete left the earth skimming along the ground. Unfortunately, the insufficient stability of the device did not permit, of continuing without being rash, this attempt, the result of which, although by no means negligible, indicated the necessity of new investigations.

Mr. Ader is, in aeronautics, a zealous adept of the strict imitation of nature; he never varies from it 2385
without a deep regret. We shall see, by the description of the sustaining surfaces, that no complication of mechanism rebuffs his patience or alters his robust conviction. Our personal manner of looking at the problem is too different from that of the author for us not to limit ourselves to this simple statement. Moreover, if various parts of his work seem more particularly to invite criticism, such as the method of establishing the sustaining surfaces, weak on account of their general mobility,

2386 the projecting and orthogonal position of the condenser, a cause of parasitical substantial resistances, etc., it is none the less necessary to observe that the author has been obliged, in order to realize his project, to surmount difficulties of construction extremely arduous, and to render a merited homage to him.

Let us regret only, for the *Revue*, that Mr. Ader has limited himself to a purely descriptive setting forth and has judged it premature to furnish us the numerical data that we should have liked to present to our readers.

2387 The writer uses the word "avion" (from "avis" bird) to designate his winged machine; we have thought it best, however, to preserve to it the name of aeroplane. In fact Mr. Ader's machine has a propeller independent of a fixed sustainer. On the other hand, mechanical birds to which the designation of "avion" would better apply, are characterized by the union, in their flapping wings, of the two functions; sustentation and propulsion.

The sustaining surfaces of the Ader machine are without doubt not absolutely fixed, but their relative and temporary mobility does not determine the propulsion; it only modifies it. The propelling
2388 movement therein is continuous and circular; it is, on the contrary alternative with the bird, natural or artificial.

The characteristic which differentiates the Ader aeroplane most from the earlier aeroplanes, of Penaud or Maxim, for instance, consists in the fact that Mr. Ader seeks to obtain, principally by the aid of variations in the shapes and positions of his *sustaining surfaces* properly so-called, the results which the majority of other experimenters seek especially in the action of distinct *auxiliary surfaces*, automatic or not automatic.

This difference appeared, therefore, to us, to rest 2389
only on a secondary point and seemed to us insufficient to justify the use of a new expression adapted to characterize the class of artificial flyers which were neither mechanical birds nor aeroplanes.

Preamble.

The flight of birds and insects has always interested me. During my youth, the idea of making a mechanical flying bat having occurred to me, I forthwith undertook the task.

This little machine had two concave wings made of wicker and paper; in front, a propeller—also
made of wicker and paper—replaced the wings of 2390
the living insect; furthermore, the apparatus was furnished with a tail (Fig. 24).

A spring and cog-wheels made the propeller turn and small tube partly filled with quicksilver was adapted to lower or elevate the tail, according as the apparatus tilted forward or backwards. But, to my great despair, however much I stretched the spring and greased the cog-wheels, the machine always fell back to the ground. I began again with so much the more perseverance since the small results obtained were appreciable.

I succeeded fairly well in causing small machines
to fly to a few metres distance; but the larger I 2391
made them, the harder it became, and above a certain size the difficulty increased in a discouraging manner. I had tried all kinds of birds' wings, bat-wings and insects' wings, disposed as flapping wings or as fixed wings in conjunction with a propeller, and I had designed motors for each case.

Only then was I able to fathom the depth of all the difficulties to overcome, and to perceive the fearful distance which separates the original conception from the ultimate realization of the problem. Completing experimentally my first theory on flat and curved surfaces in movement Fig. 24 through

2392 the air and the resistances that they meet, I dis-
covered the important universal curve of flight or
sustentation. I finished the study of the flight of
the large birds in their habitats, that of the storks
at Strasburg, that of the voutures in Algeria, at
Constantine. I had some Indian vampires fly in my
laboratory and sought from anatomy the construc-
tive secret of the frame works of flying animals.

At last, after having carried out some of my
ideas of flying machines, I undertook from 1882 to
1890 the construction of the "Eole" which was
tested the 9th of Oct. of this latter year and to
which the description which is about to follow
2393 refers.

The future winged machines for the realization of aerial navigation will not flap their wings. To fly they will constantly soar. Their concave wings will support them and a propeller placed in front of them will guide them forward and keep up their speed.

The motive force will be furnished by steam appropriated to this particular use.

They will always essentially consist in—1, a body; 2, wings; 3, motive power; 4, the propeller.

Without one of these parts, the aeroplane could
not exist. We will describe them consecutively and
2394 enumerate the new principles which are applied to
them.

FIRST CHAPTER.

Body of the Aeroplane.

The body of the aeroplane is built in such a fashion as to sustain the organ which it contains, to be supported itself by the wings during flight and in its turn to support the whole machine on the ground. Sheets XII to XV and Figure 25 shows its principal lines. We can designate the different parts 2395

Shoulder, the large joint on which the wings are articulated;

Beak, its extreme forward part carrying the propeller;

Neck, that part where the engine is located;

Back, the upper part which receives the condenser and which lets the chimney pass through;

Inside, the location of the generator;

Sides, the part which carries the fuel tanks;

Feet, composed of wheels or of skids with an intermediate sliding surface suspended on springs, of which two are placed laterally, another in front 2396
and a fourth behind, to guide the course of the aeroplane when on the area.

The aviator is seated at the rear, in V (Sheet XIII). The controlling apparatus are within his reach. When the aeroplane has a vertical rudder it is fixed in the same plane as the rear wheel, and is manœuvred in conjunction with it. The body of the machine is enclosed from one end to the other in an impermeable covering.

SECOND CHAPTER.

Sustaining Wings.

I.—Universal Curve. 2397

Whatever may be the class of wings, they are essentially curved from front to back, in relation to the direction of translation—according to a special curve which is found to be a spiral (Figs. 26 and 27). We know that it is the property of a spiral to turn around the center from which it is constantly getting further away and that all tangeants to no matter what point of the curve form similar angles with the radius; one can thus draw more or less curved spirals.

This curvature is indispensable to a moving sur-

2398 face to enable it to obtain the maximum support in the air. It is also applicable and indispensable to the individual feathers and the blades of propellers.

One can call it the universal sustentation curve of flight and support in the air.

The centering as regards the extent of the curvature of the concavity of the wings, will change according to the speeds and loads, but without ever losing the character of a spiral. For all wings, without exception, small or large, the central or starting point C of the spiral curve coincides with the front of the wing, the Figures
2399 26 and 27, representing two absolutely similar spirals, afford an example of this. On that of Fig. 26, we see a full line which shows the shape of a large wing; on Fig. 27 the full line represents another wing, much smaller. The horizontal lines indicate the direction of translation. One and the same wing may change its degree of curvature during flight but it will only be a modification of the spiral.

II.—Laws Common to all Wings.

All wings, of whatever shape and nature they be, must obey the same laws. It cannot be other-
2400 wise, because the difficulties of locomotion in the atmosphere especially when the latter is disturbed, and the starting and landing manœuvres on the field will be the same for all aerial machines. Aeroplanes will also inevitably undergo great changes in their weight through the consumption of fuel or by the lightening of the load, should any part of the load be left to fall to the earth.

From all this arises the necessity of being able to steer and to diminish or increase the speed of translation. And to be able to attain this end it is necessary that the wings should be capable of making in flight four principal movements: 2401

1. To move forwards or backwards in their entirety.

2. To fold up, so as to diminish or extend their surface.

3. To warp.

4. To change at will the centre of the universal curve.

All the combinations of frameworks, of articulations, of tendons and membranes are made with this end in view. 2402

Because of the great difficulties which accompany the question of speed, we have been obliged to make wings for slow speed and high speed machines.

III.—Low Speed Wings.

They are of the bat-kind—(Sheet XIV, Fig. 1). Their frame work consists of an S shaped arm B; of a fore-arm A B curved forwards and at the same time downwards; of a hand M carrying the thumb and four fingers D1, D2, D3, D4, having phalanges—these fingers and these phalanges have curves appropriate to the shape of the wings. 2403

All parts in the frame work are articulated in such a manner that one can make them assume the positions necessary for flight. The arms fold against the body, the forearm folds on the arm and the fingers fold up against the forearm; the legs follow these movements because of the connecting-rod L. It is this folding or manœuvre which is destined to increase or diminsh the surface of the wings.

Furthermore, the phalanges of the fingers can

2404 be lowered or raised vertically; it is the same for the feet. This operation which is destined to increase or diminish the arching of the universal curve is shown in Fig. 28.

Aside from this the elbow U turns on itself, and consequently carries with it the forearm, the hand and its fingers. This action is for the purpose of warping the tip of the wing, so as to destroy or reestablish equilibrium in the wings.

There is another general movement which consists in carrying the whole wing forwards or backwards by making it pivot on its shoulder joint.

2405 The object of this capital movement is to place in equilibrium all the centers of action of the air on the wings with the center of gravity of the aeroplane. These manœuvres are conducted from the inside of the body when in full flight, by means of tendons. The intervals between the members are filled by membranes. There are membranes between the fingers; in front is an angle membrane V, held by the arm and forearm; a large membrane is attached to the fourth finger, to the forearm, to the arm, to the body and to the legs; lastly, there is a tail membrane. (Sheet XIV.)

The membranes are traversed by "lines of force"
2406 or stretching braces; their directions are curved, the arched shape which is seen at the rear of the membranes is the final consequence of the curvatures of these "lines of force." In certain parts of the wing these "lines of force" may be rigid; then, in this location the membranes keep the same surface; but their essential characteristic is to be elastic, so that when the members are folded up the membrane always remain stretched. This, of course, facilitates the operation of increasing or decreasing the wings' surface.

At rest on the ground, the wings are completely folded up. This faculty enables the securing of them against the action of the wind and the housing them more easily as is seen in Fig. 29. 2407

The membranes are stretched by antagonist tendons located forward on the fingers and the action of stretching them can be graduated at will.

At the rear it is the legs which provide the resistance.

IV.—High Speed Wings.

They are of the bird-kind as regards their frame work, with membranes in the intervals (Sheet XIII, Fig. 1). Their frame work consists in an S shaped arm B and in a two piece forearm A B. 2408
The principal piece is curved backwards, the other follows the curvature of the latter, less so, however, near the elbow; both are equally curved downwards. At the end of the forearm is the hand M.

As was explained for the slow-speed wing all these members fold up to obtain the different positions which the act of flight requires.

The angle membrane V, between the arm and forearm, is similar to that of the slow speed wings; it is, however, slightly narrower.

The members of the wings carry ribs (T) which are substantially curved both horizontally and vertically. They are attached to the members by ar- 2409
ticulations and tendons which belong only to them; they can fold up at the same time as the members of the wing and can follow the movements of the latter. These ribs have the special faculty of being able to turn on themselves all at one time, and, because of their curved longitudinal shape, one can by the aid of these gyral movements, give to the universal curve the desired degree of curvature. The intervals between the ribs are occupied by membranes which are elastic, and therefore, always taut.

2410 The tail is made with ribs like those of the wings and furthermore, it can have below, and even above, a vertical rudder Z which can be seen on Sheet XII. These two rudders are operated from the inside.

V.—Details of the Framework and of the Tendons of the Wings.

Here are first those of the low-speed wings; each wing taken as a whole is held in place by a pectoral tendon P, articulated in the prolongation of the shoulder-joint, and fixed below to the sides of the body of the aeroplane and above to the arm of the
2411 wing (Fig. 25).

The forearm A B is connected with the arm B by the elbow (Fig. 30 and sheet XIV, Fig. 1), a tendon C keeps it up and another tendon D keeps it down and supports the strain during the action of flight. The forearm turns upon itself at the elbow, thanks to the tendon T and pulley. These tendons T of the left and that of the right are connected together so as to compensate each other; to avoid the concussion of sudden strains they are furnished with an auxiliary muscle M in their course. These tendons are governed by other tendons C and D^2 coming from the inside and put in
2412 motion by the pedals L, or other devices.

Above the elbows there is another tendon E making similar movements. Thus then when one forearm turns one way, the other turns in the opposite one.

The forearm closes horizontally on the arm by the aid of the tendons P^2 and D3 (Fig. 31) which are worked from the inside.

The fingers are articulated to the hand and there held up by tendons; other tendons underneath keep them down and support the strains during the action of flight. These tendons are approximately like those C and D of Fig. 30. Horizontally they are strongly drawn forward by the tendons H and P (Sheet XIV and Fig. 31) to stretch the membranes. These tendons are at their origin attached to the arm B, so that the more the forearm A B opens, the more the fingers are drawn forward and stretch the membrane, at the rear tendon, N is attached to the arm on the spur. 2413

On looking at the figure it is seen that, by the operation of folding the forearm on the arm, which is done from the interior, one also folds up the fingers, and consequently relaxes the membrane or stretches it; the surface of the wings is diminished or increased. Furthermore, when it is necessary to operate a high tension, the thumb is lifted up by the tendons R and pulley (Fig. 32) and as the tendon P is rigid and fixed to the shoulder it carries the first and second fingers forward and strongly stretches the membranes. 2414

Figure 33 shows in diagram an arrangement of the tendons for working the phalanges of the fingers and of the feet. These tendons are worked by levers, such as L; everything is in perfect equilibrium. During flight the action of the air under the wings meets there its resistance, but if one or the other of the levers is worked separately, as can be seen by noting the course of the tendons, the equilibrium is destroyed and the resistance to the air changes in location by the fact of the changing of the inclination of the phalanges; if the two levers are lowered at once the equilibrium is not destroyed, but all the phalanges are lowered and there is an accentuation in the curvature of the spiral or universal curve of flight. In this diagram only the tendons of one phalange per finger are represented; it is, of course, the same for the other phalanges. One can, moreover, vary these combinations in order to work the phalanges separately. 2415

2416 To hold the forearm extended and open (Sheet XIV, Fig. 1) there is along the connecting rod L a tendon B′ attached to the knee and to the arm; this tendon helps to extend the forearm and helps the tendon D3, which we have seen on Fig. 31.

The legs of the feet are strongly stretched by tendons X which are seen on Sheet XIV. A forward movement draws the leg forward, and inversely, a movement backwards forces the legs to do likewise; this arrangement is necessary for the regular stretching of the feet on the large membrane.

To carry the entire wings forward or backwards the tendons are arranged as on Sheet XIV. By
2417 pulling tendon C, the wing is drawn forward; by pulling tendon B2 it is carried backwards; and so it is with the tendons A′ and B′ which are safety tendons. The control of these tendons is affected from the inside by windlasses or other devices.

The details of high speed wings differ slightly from those just described as can be seen on the portion of the frame-work on Fig. 34. The forearm is composed of two pieces, the forward one A′, B′, is more slender than the principal one A B; they are both articulated on the arm B of which a portion is visible; the hand M is articulated on the forearm; this hand is in two pieces and its extremity M′ is
2418 articulated.

The tendons P and D cause the forearm to open and close upon the arm; independently of these there are others underneath, not shown on the figure, and intended for moving the forearm on itself as for the slow speed wings (Fig. 30).

The small tendon S controls the forward piece of the forearm, which is similarly acted upon underneath; the tendon N and F pull on the hand, they are represented as cut off on the figure, but there are attached on the arm, at the elbow, respectively,

in front and behind, so that the bending of the fore- 2419
arm brings about also the bending of the hand, as was explained for the slow-speed wing; these tendons are checked in this automatic movement by other tendons voluntarily put in motion from the inside.

The extremity of the hand M is dependent on the bending of the whole hand, through the tendons X and Y; this bending takes place in the same direction. The hand is raised or lowered by other independent tendons, of which there are two principal ones, one on the body of the hand M, the other at the back on a spur T belonging to the body of
the hand (Fig. 35). It is the same underneath, 2420
from the arm to the hand; beneath the forearm A B, is a large tendon T′ shown on Figure 36.

The ribs of the membrane or feather carrier U are articulated on the principal piece A B (Fig. 34). These ribs have stretchers or small tendons z, underneath, which pass under the tendon T′ of Fig. 36; and are attached to the forward piece of the forearm A′ B′, so that the more the tendon stretches the more it stretches that of the ribs. This mounting is seen better in Fig. 37 where there are seen in section the three points necessary for attachment of the ribs, first the thick piece of the forearm
which acts as a buttress to the rib; then the slender 2421
forward piece which serves for attachment to the small tendon of the rib; lastly the thick tendon running beneath the forearm, which keeps the rib lowered.

As to the direction of the axes and the numerous details of the articulations, their complexity would render any description of them difficult.

VI.—Method of Construction of the Articulations, Framework, Tendons, Etc.

The pieces of the frame-work are hollow, made

2422 with wood and bamboo fibres, beveled together. Occasionally they are filled internally with elder pitch, cork, or light putty. When the pieces have to undergo a torsion, the fibres are given a helicoidal direction. Later on these will be able to be made of metal.

The fixed tendons or stretchers are of fibre of bamboo or other wood. The eyelets, chapes, patellas, cranks, axes, spurs, blocks, etc., which go to make up the articulations are obtained with the main pieces themselves by bending and warping the fibres of which they are composed. This is also the case for the fasteners of the stretchers or at-
2423 tachments of the tendons.

To fix and fasten these different materials, cloth, fibres, felts, ligaments, gelatins and impermeable cements are made use of.

The tendons for movement slide over or turn about pulleys; they are of silk cord, or cat-gut, or metallic wires.

The membranes are of impermeabilised silk and cover the entire upper part of the machine. The elasticity of their line of force is obtained through small metallic springs or through hard rubber elastics placed very close together and incased in sheaths.

2424

VII. Variation in the Shape of the Wings.

The high speed wing could be in every respect similar to that of birds by putting artificial feathers in the place of the membranes which are between the ribs. The description of the artificial feathers will be found in the chapter dealing with the propeller. Figure 38 shows these wings; the feathers of the wing-tips are lifted by the action of the wind; the first one is the one most lifted, the second less, the third still less and so on up to the

eighth in the line. Unfortunately the manufacture 2425
of these feathers is extremely costly.

To simplify a wing of the bat-kind one could do away with all or a part of the elasticity of the membrane and also paralyze the movements of certain limbs, keeping only the fixed universal curve and the horizontal pivoting of the wings at the shoulder, which are indispensable. However, with such a wing one can indeed maintain himself in the air, but only under favorable atmospheric conditions.

The simplification can be carried further by making the wings like those of Fig. 39, and still further
as in Fig. 40. Finally, the extreme limit is repre- 2426
sented by Fig. 41. To sum up, the rational shapes of the low and high speed wings, described previously, are those which best suit aeroplanes destined to fly in all weathers and whatever may be the state of the atmosphere.

It was necessary to borrow these two grand types from nature, as well as the principles; impossible to do otherwise, esteeming ourselves very fortunate, not to attain them but to approach them a little. We have not spoken of the means and theoretical considerations which served to establish the exact shapes and dimensions of the frame-works and
membranes, for they are extremely complicated and 2427
the explanation of them would be too long.

SUMMARY.

Thus, as regards the wings of the aeroplane, the essential principles and means used by us are notably: the universal curve of sustentation applied to the wings and to their independent propeller.

Mobility of the wings at the shoulder joint in a horizontal direction which enables them during flight to be carried, forward or backward, in order

2428 to place the center of pressure of the air on the surfaces in equilibrium with the center of gravity of the aeroplane.

Partial folding up of the members of the wings during flight, so as to diminish or increase their surface according to the necessities of the speeds or of the evolutions.

Turning movement of the forearm around the elbow or any part of the wing, to warp it.

Vertical movement of the phalanges of the fingers for the bat-like wings, and gyral movement of the membrane-bearing ribs for the bird-like wings so as to vary at will, during flight, the degree of
2429 curvature of the universal curve of sustentation under the wings.

Elasticity of the membranes connecting the members of the ribs, so that their surface may always be taut whatever may be the degree of folding.

Curvature of the lines of force or stretchers which spread their net-work over the membranes, whether these lines of force be elastic or not.

Complete folding up of the wings on the ground to withdraw them from the action of the wind and to reduce the volume of the aeroplanes.

Variety of the wings.

Rear-wheel steered with the vertical rudder for
2430 landing purposes.

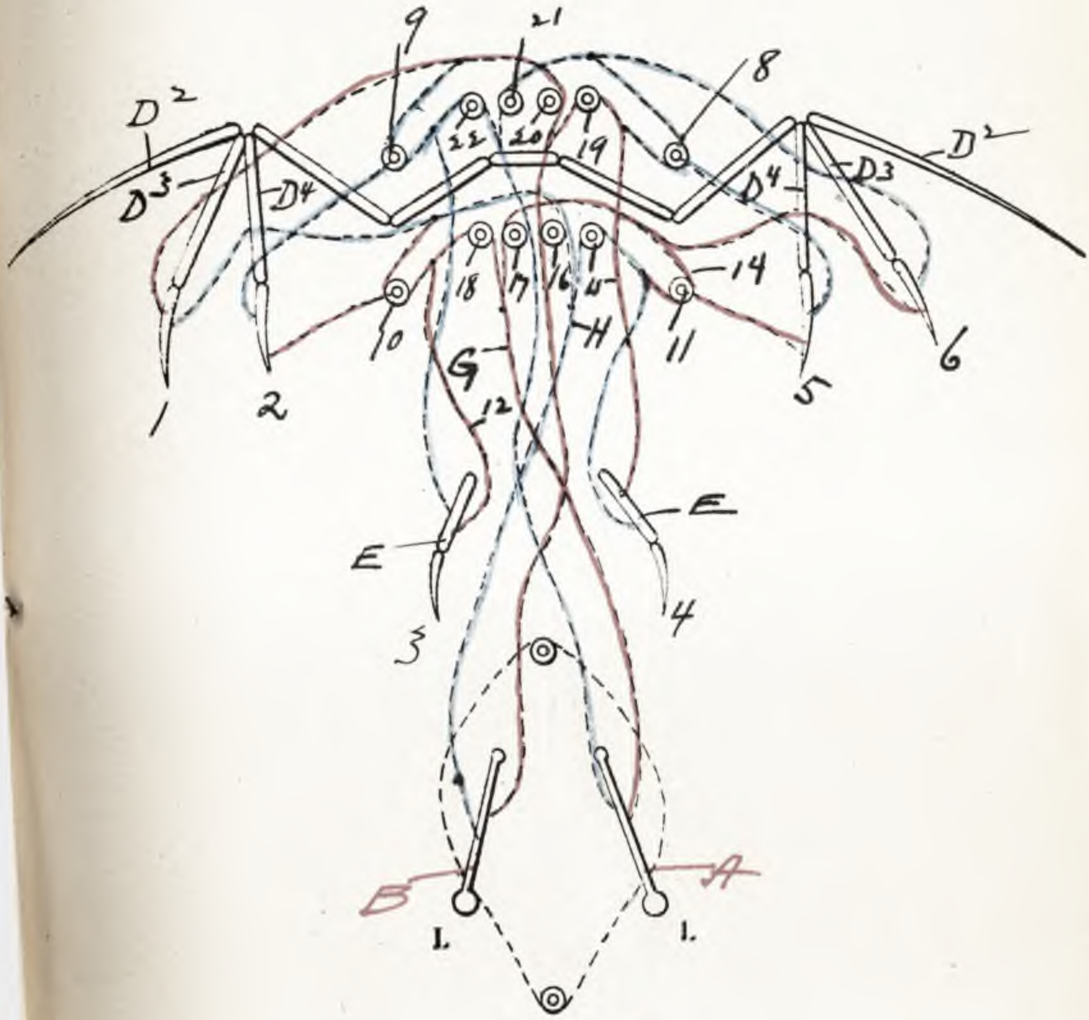

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Fig. 33 A

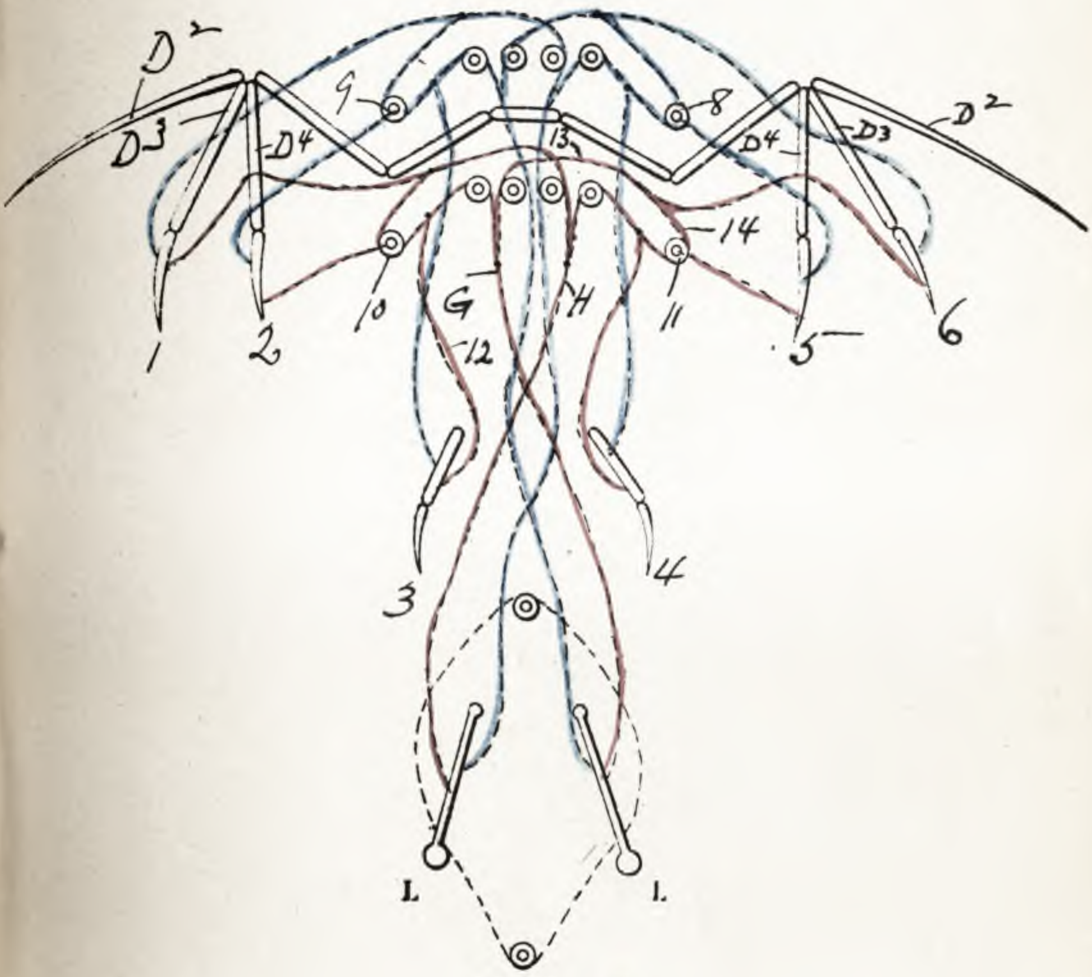
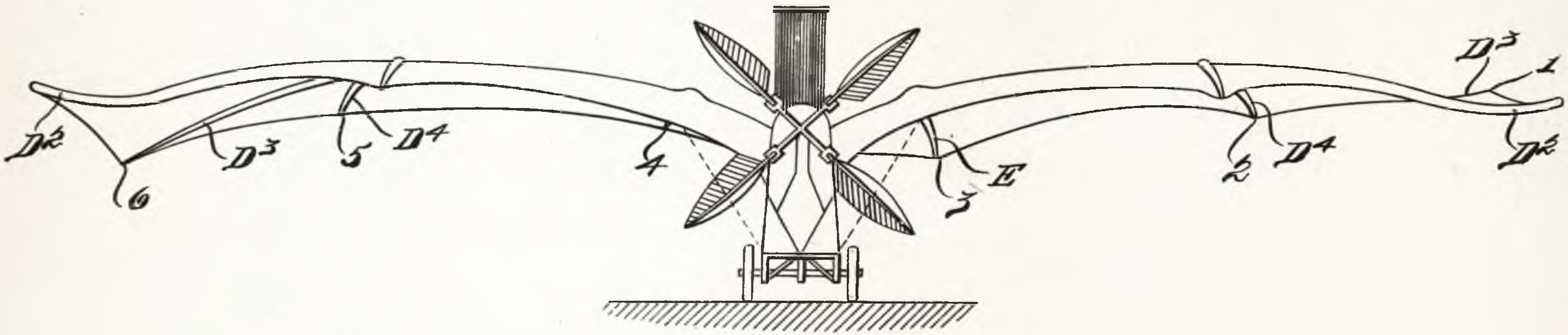


Fig. 33 B



"DEFFENDANT'S EXHIBIT- DRAWING ADER WINGS WARPED"

2440 **Defendant's Exhibit Complainant's Answer in Lamson Suit.**

UNITED STATES CIRCUIT COURT,

SOUTHERN DISTRICT OF OHIO—WESTERN DIVISION.

CHARLES H. LAMSON *v.* THE WRIGHT COMPANY.	In Equity No. 6611.

2441 **Answer.**

The answer of The Wright Company to the bill of complaint herein.

This respondent, now and at all times hereafter, saving and reserving to itself all and all manner of benefit and advantage or exception or otherwise that can or may be had or taken to the manifold errors, uncertainties, imperfections and insufficiencies in said bill of complaint contained, for answer thereto, or unto so much and such parts as it is advised it is material or necessary for it to answer, unto, answering, says:

2442 (1) This respondent denies each and every allegation in said bill of complaint contained, except such as are hereinafter admitted or specifically answered or avoided.

(2) Respondent admits that it is a corporation existing under the laws of New York, with a factory and office in Dayton, Montgomery County, Ohio.

(3) Respondent denies that, as alleged in paragraph numbered 1 of said bill, Charles H.

Lamson was the true, original and first inventor 2443
of the improvements referred to, and requires strict proof of said averments; and also denies all the other averments of said paragraph.

(4) Respondent admits that an alleged patent No. 666,427 issued on the 22nd day of January, 1901, but whether the same was procured as required by law, and as averred in paragraph numbered 1 of the bill, respondent is not advised and demands strict proof thereof.

(5) Respondent, further answering, denies that the kite or apparatus of the patent sued on is of great value and has been practiced; and that long 2444
prior to this action respondent was notified of said patent, but has since continued to use, sell and lease apparatus embodying the alleged invention, as averred in paragraph 3 of the bill.

(6) Respondent, further answering, says that it is not informed, save as averred in paragraph 3 of the bill, whether the trade and public have acquiesced in the patent sued on or whether complainant has actually enjoyed any rights thereunder, and, therefore, leaves complainant to prove said allegations; but denies that respondent has in any wise infringed or committed any wrongful act against the alleged rights of complainant as er- 2445
roneously averred in said paragraph 3.

(7) Respondent, further answering, denies, as alleged in paragraph 4 of the bill, that it has since November 27th, 1909, or at any other time, made, used, sold or leased any flying machines or other apparatus embodying the alleged invention embraced in the patent sued on or otherwise infringed upon said patent or trespassed upon any rights of complainant, or has threatened to do so or is now doing so, or has committed any injury, irreparable or otherwise, to complainant as erroneously averred in said paragraph.

2446 (8) Respondent, further answering, avers on information and belief, that the so-called kite set forth in the patent sued on was never manufactured or sold, was never used by the public, has never gone beyond the experimental stage, is not a practical thing, is without utility and would not constitute a flying machine and is not capable of enabling man to fly, has never flown or carried a human passenger, could not be controlled in the air by an operator, has no means of effecting such control, either shown or described in the patent and that the patent nowhere sets forth any means or any thought or idea of the kite or thing of the
2447 patent performing any of these functions or being capable of control or maintaining balance obedient to the will and necessities of an operator riding on the same, for which several reasons the patent is null and void.

(9) Respondent, further answering, shows the Court that although the application for the patent sued on was filed in the Patent Office May 9th, 1900 the historical fact is that human flight or a heavier-than-air machine capable of carrying one or more persons and manageable as to direction and the maintenance of lateral and fore and aft balance by
2448 the operator on the machine, while speeding through the air, did not become a known fact and had not been accomplished until the 17th day of December, 1903, when the labors and previous long years of experiment of respondent's assignors Messrs. Wilbur & Orville Wright, culminated in at that time opening the era of human flight in heavier-than-air machines propelled through the air; and that accordingly the apparatus of respondent complained of herein, as respondent supposes, is none other than this new creation of Wilbur and Orville Wright, and is embodied in letters patent of the United States dated May 22nd, 1906, No.

821393, issued to Orville and Wilbur Wright on their application filed in the United States Patent Office March 23rd, 1903, under and in accordance with which respondent has made, use and sold its only flying machines; and in the procuration of which Wright letters patent the Patent Office of the United States made no citation or reference to the patent sued on herein, although it was in the archives of the Patent Office at that time, a fact from which respondent avers that the Patent Office officials did not regard the patent sued on as having any bearing upon the flying machine of respondent. 2449

2450

(10) Respondent, further answering, avers, on information and belief, that long prior to the alleged invention of said Lamson, as attempted to be embodied in the alleged patent sued on, kites and analogous apparatus containing all the essential features of said alleged invention, as exhibited in said alleged letters patent, had been described and exhibited in the following prior United States and foreign letters patent and publications, in view of which said alleged patent sued on is anticipated and void:

UNITED STATES LETTERS PATENT.

Mouillard, 582,757, May 18th, 1897. 2451

BRITISH LETTERS PATENT.

Henson, 9,473, of 1842.

PUBLICATION.

The Aeronautical Annual, 1897, published by W. B. Clarke & Co., Boston, Mass., pages 128 to 141, The Way of the Eagle in the Air, by E. C. Huffacker.

All of which matters and things this respondent is willing to aver, maintain and prove, as this Honorable Court shall direct, and prays to be hence

2452 dismissed with its reasonable costs in this behalf most wrongfully sustained.

H. A. TOULMIN,
Solicitor for Respondent.

October 1st, 1910.

The United States of America, Southern District of Ohio, Western Division, } ss.:

I, B. E. Dilley, Clerk of the Circuit Court of the United States, within and for the District and Division aforesaid, do hereby certify that the
2453 foregoing is a correct copy of the original answer filed October 3, 1910 as the same appears on file and of record in the Clerk's office of said Court, in the therein entitled cause.

In witness whereof, I have hereunto set my hand and affixed the seal of said Court, at the City of Cincinnati, Ohio, this 11th day of May, 1911.

(Signed) B. E. DILLEY,
[SEAL.] Clerk.

(Signed) By Harry F. Rube,
Deputy.

2454 **Defendant's Exhibit "Wright Letter of Oct. 18, 1904."**

Dear Dr. Spratt:—

Your letters of Sept. 20 and Oct. 2nd read. Congratulations to yourself and Mrs. Spratt on the birth of another George. Hope he will grow up with his heart as near the right place as his father's.

We were very much interested in your account of the trial of the large machine and regret that you did not get a more satisfactory test before the

accident when loading it. It worries me to think 2455
of your trying to handle a large machine without adequate help. It is dangerous to both man and machine. Surely you can get the help or at least presence of some neighbors when you go out again. Very often the best chances slip past because it is impossible for one man to get ready in time to utilize it. If you wish to experiment with natural winds you must be able to act quickly.

Our own experiments are progressing satisfactorily and we have had more practice during the past month than in all the rest of the season. We have gotten now so we can fly clear round the field
and return to our starting place. So we make long- 2456
er flights and do not have so much handling to do. We have not had any very long flights yet but as soon as we feel sure everything is just as we want it we will try a five mile trip.

If Mr. Reid gets out our way we will be glad to meet him and have a chat with him. We prefer however that you do not tell him that we are experimenting here, nor that we are making flights. We are not showing the machine nor letting the public know what is going on.

We thank you for the address of the Philadelphia lumber men. At present we have an abundant
supply obtained direct from the mills in West Vir- 2457
ginia, but may some time get into an emergency when a few pieces obtainable at once/ would be worth their weight in gold almost.

With best regards,

Yours truly,

Wilbur Wright.

Wilbur Wright
Orville Wright

Defendant's Exhibit
"WRIGHT LETTER OF DEC. 15,1901"

Established in 1892

Manufacturers
Bicycles
St. Clair

Wright Cycle Company
1127 West Third Street.

DAYTON, OHIO, Dec 15 1901

Mr. G. A. Spratt
Coatesville. Pa

Dear Sir.

We were pleased to receive your letter and the photograph of your new testing machine. It seems quite ingeniously designed and I think should give good results. As you say the greatest trouble will probably be with the changeableness of the wind. If I understand you properly, the machine is intended for locating the centre of pressure at any angle (or rather locating the angle for any centre of pressure) and for finding the direction of the resultant pressure as measured in degrees from the wind direction ~~normal~~ so that the ratio of lift to drift is easily obtained, the lift being the ~~sine~~ Co-tangent and the drift being the tangent of the angle at which the arm stands. Does the machine also measure the lift, in terms of percent of the pressure at 90°, so that you can make tables like that of Lilienthal?

I think I told you in my last that we had been experimenting with a "lift" measuring machine. We have carried our experiments further and have made a measurement of the lifts of about 30 surfaces at angles of 0°-2½°-5°-7½°-10°-12½°-15°-17½° 20°-25°-30°-35°-40°+45°. The results have rather surprised us as

Wilbur Wright
Orville Wright

Established in 1892

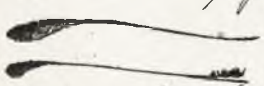
Manufacturers of Van Cleve Bicycles St. Clair

Wright Cycle Company

1127 West Third Street.

DAYTON, OHIO, ...

we find at angles of 7° to 15° with some surfaces a greater lift than Lilienthal gives in his table. Our #7 surface which is a rectangle 1:6 with a depth of curve of 1/12 the chord ~~that the~~ has a "lift" of one hundred and nineteen per cent at 17½ degrees. Lilienthal only claims about 80 percent. But at 3° our measurement is way below him. I will try to send you a blue print ~~of~~ showing the lifts of some of the surfaces we have tested. Some surfaces which lift big at very small angles are no good at large angles & vice versa. We have not attempted to ~~measure~~ trace the travel of the centre of pressure except that by holding some of the surfaces between the tips of our fingers we were able to roughly determine which ones tended to reverse and which did not. It seems that surfaces with rather flat upper sides and thickened front edges lift more at small angles than plain curves and have little reversal of the travel of the centre of pressure. Thickening the front edge ~~to~~



does not seem to add near as much to the drift as I expected though it adds some. We have found less drift with surfaces 1/20 deep than with curves 1/12 deep. What is your experience?

Wilbur Wright
Orville Wright

Defendant's Exhibit
"WRIGHT LETTER OF MAY 24,1903"

Established in 1892

Manufacturers Bicycles

Wright Cycle Company

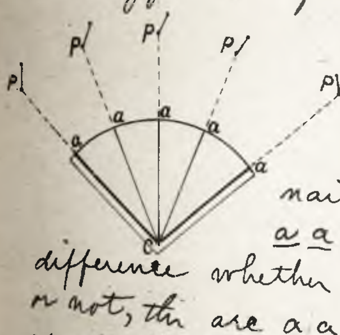
1127 West Third Street

DAYTON, OHIO, May 24, 1903.

Dear Doctor;

I see that in some respects we are in agreement and in others we do not agree at all. We agree that a segment of a cylinder will not move if pivoted at ~~its~~ center of cylinder upon a fixed axle. But when we come to consider flying conditions you see similarities where I can see none. I tried the experiment you suggested but as I used a surface of the lightest possible material instead of tin, and used a heavy chunk of metal for the weight in order to reduce its resistance below that of a nail placed transversely, the results were quite different from those you described. I think that in your experiment the center of gravity and the center of pressure were both too near the center of the entire structure. 

I suggest the following method of studying the problem.



Cut a piece of paste board or tin to the shape of a quarter circle and pin it against a wall by driving a nail at the center c. Drive other nails at P P &c and connect these nails to the perimeter of the circle at the points a a by rubber bands. Now it makes no difference whether the rubbers are stretched equally tight or not, the arc a a will not rotate. Neither will it rotate if all the ~~bands~~ rubbers are cut but one, no matter which

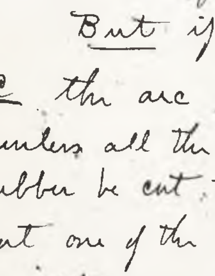
Wilbur Wright
Orville Wright

Established in 1892

Van Cleve
Manufacturers of
Wright Cycle Company
Bicycles
1127 West Third Street
DAYTON, OHIO, ____________

one is left. This is the case of your cylinder pivoted at the center. If we keep clearly in mind that there can be no action without a reaction, and that they must be exactly equal, and exactly in opposite directions it is clear that while the cylinder segment is exactly in equilibrium in all directions, the center c is under unequal strains and will ~~be~~ tend to be moved to right or left according as the right or left rubbers are drawn tightest. As the point <u>c</u> is capable of greater resistance than the force tending to move it the whole structure remains motionless regardless of difference in strains and regardless of how many or what rubbers are cut.

<u>But</u> if a <u>weight</u> is substituted for the pin at <u>c</u> the arc <u>a a</u> will immediately change its inclination unless all the rubbers pull equally. If all but the center rubber be cut the arc will still be motionless, but if all but one of the others, be cut, the arc will tilt up till the weight comes in a <u>vertical line</u> with the point of suspension. The dotted lines show the position at the moment



the rubbers are cut; the solid lines the new position it takes. If two rubbers are left uncut, but one with greater strain than the other the structure will take a position with the <u>resultant</u> vertical and the weight will fall in line with it. If the weight had been hung at a point a little above or below the center <u>c</u> the tilting

Wilbur Wright
Orville Wright

Established in 1892

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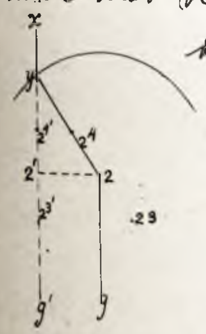
Manufacturers of Bicycles
Wright Cycle Company
1127 West Third Street
DAYTON, OHIO,

would yet be in the same direction. The principle involved is this that ~~it~~ since the only reaction is the weight which pulls vertically downward, therefore the only action that can be exerted upon the surface must be vertically upward and the lines of the two forces must coincide. If the pressure on the surface is at first in some other direction the surface must rotate or tilt till ~~it~~ the resultant pressure becomes vertical, and even if vertical it must also be in line with the weight. Thus a surface



having a vertical pressure at the point y will not be in equilibrium unless the weight z is moved to z' thus bringing g into line with y and x. The weight must move or the surface must tilt. The distance from the center does not prevent the tilting, but slightly affects its force. the tilting force increases with distance from surface. If the weight had been at y there would be no tilting if the force x y had been applied.

Applying this results of this system of experiment to your floating cylinder, the conclusion is that while there is no force tending to rotate the cylinder around the center, there is a force tending to rotate the center around the cylinder segment. and in practical flight the effects are similar because a weight pulling vertically gives no horizontal reactions to prevent it from ~~not~~ starting to rotate around the wings.

Wilbur Wright
Orville Wright

Established in 1892

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Manufacturers of Bicycles

Wright Cycle Company

1127 West Third Street

DAYTON, OHIO.

It is the experience of both birds and men that a center of gravity about on a line with the surface gives the best results. The buzzard hangs below and pays the penalty of its laziness by its unsteady flight as compared with hawks.

As I understand the Lilienthal catastrophe he was floating along when a wind gust with an upward trend struck him and caused the center of pressure to move slightly forward (arched surface with larger ang. incidence) this caused the machine to ~~rise~~ turn up in front and loose headway. The reduced speed made the ang. of incidence still greater and moved the c of pressure still farther forward. He moved ~~his~~ forward to lighten turn the machine ~~down~~ down in front. But the gust suddenly dying out with a downward trend the center of pressure suddenly moved way back far beyond the point to which he was able to move his body backward, so the surface ~~d~~ tilted forward with a "bang" and probably broke the stop which prevented the tail from falling below a certain point. (It was free to fold upward you remember). In this position the speed increased rapidly, and with the smaller and smaller angle of incidence the c of pressure moved farther and farther back and turned the surfaces ~~up~~ over more and more till it turned entirely over and struck the ground with fright. full velocity partly up side down.

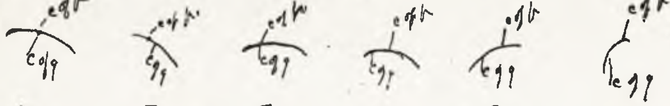

Fig 1. Fig 2 Fig 3 Fig 4 Fig 5 Fig 6

Yours truly
Wilbur Wright

Defendants' Exhibit

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CXXXII.

SOME AERONAUTICAL EXPERIMENTS.

Mr. Wilbur Wright, Dayton, O.

Presented September 18, 1901.

INTRODUCTION BY PRESIDENT CHANUTE.

Engineers have, until recent years, fought shy of anything relating to aerial navigation. Those who ventured, in spite of the odium attached to that study, to look into it at all, became very soon satisfied that the great obstacle in the way was the lack of a motor sufficiently light to sustain its weight and that of an aeroplane, upon the air. Fifteen years ago the lightest steam motor was the marine engine weighing 60 pounds to the H. P., while the gas engine weighed very much more; the locomotive weighed 200 pounds per H. P. During the past fifteen years a great change has taken place. Steam motors have been produced weighing only 10 pounds per horse power, and gas engines have been lightened down to 12½ to 15 pounds per horse power, so that the status, so far as engineers are concerned, is very greatly changed, and there is some hope that, for some limited purposes at least, man will eventually be able to fly through the air. There is, however, before that can be carried out—before a motor can be applied to a flying machine—an important problem to solve—that of safety or that of stability.

I had the honor of telling you, some four or five years ago, something about the progress that had been made up to that time. Since then further advances have been make by two gentlemen from Dayton, Ohio,—Mr. Wilbur Wright and Mr. Orville Wright, who tried some very interesting experiments in October, 1900, about a year ago. These experiments were conducted on the sea shore of North Carolina, and were again resumed last July. These gentlemen have been bold enough to attempt some things which neither Lilienthal nor Pilcher nor myself dared to do. They have used surfaces very much greater in extent than those which hitherto had been deemed safe, and they have accomplished very remarkable results, part of which it was my privilege to see on a visit which I paid to their camp about a month ago.

I thought it would be interesting to the members of this society to be the first to learn of the results accomplished, and therefore, I have the honor of presenting to you Mr. Wilbur Wright.

The difficulties which obstruct the pathway to success in flying machine construction are of three general classes: (1) Those which relate to the construction of the sustaining wings. (2) Those which relate to the generation and application of the power required to drive the machine through the air. (3) Those relating to the balancing and steering of the machine after it is actually in flight. Of these difficulties two are already to a certain extent solved. Men already know how to construct wings or aeroplanes, which when driven through the air at sufficient speed, will not only sustain the weight of the wings themselves, but also that of the engine, and of the engineer as well. Men also know how to build engines and screws of sufficient lightness and power to drive these planes at sustaining speed. As long ago as 1893 a machine weighing 8,000 lbs. demonstrated its power both to lift itself from the ground and to maintain a speed of from thirty to forty miles per hour; but it came to grief in an accidental free flight, owing to the inability of the operators to balance and steer it properly. This inability to balance and steer still confronts students of the flying problem, although nearly ten years have passed. When this one feature has been worked out the age of flying machines will have arrived, for all other difficulties are of minor importance.

The person who merely watches the flight of a bird gathers the impression that the bird has nothing to think of but the flapping of its wings. As a matter of fact this is a very small part of its mental labor. To even mention all the things the bird must constantly keep in mind in order to fly securely through the air would take a considerable part of the evening. If I take this piece of paper, and after placing it parallel with the ground, quickly let it fall, it will not settle steadily down as a staid, sensible piece of paper ought to do, but it insists on contravening every recognized rule

Lilienthal's Machine.

of decorum, turning over and darting hither and thither in the most erratic manner, much after the style of an untrained horse. Yet this is the style of steed that men must learn to manage before flying can become an every day sport. The bird has learned this art of equilibrium, and learned it so thoroughly that its skill is not apparent to our sight. We only learn to appreciate it when we try to imitate it. Now, there are two ways of learning how to ride a fractious horse: one is to get on him and learn by actual practice how each motion and trick may be best met; the other is to sit on a fence and watch the beast awhile, and then retire to the house and at leisure figure out the best way of overcoming his jumps and kicks. The latter system is the safest; but the former, on the whole, turns out the larger proportion of good riders. It is very much the same in learning to ride a flying machine; if you are looking for perfect safety, you will do well to sit on a fence and watch the birds; but if you really wish to learn, you must mount a machine and become acquainted with its tricks by actual trial.

Herr Otto Lilienthal seems to have been the first man who really comprehended that balancing was the *first* instead of the *last* of the great problems in connection with human flight. He began where others left off, and thus saved the many thousands of dollars that it had theretofore been customary to spend in building and fitting expensive engines to machines which were uncontrollable when tried. He built a pair of wings of a size suitable to sustain his own weight, and made use of gravity as his motor. This motor not only cost him nothing to begin with, but it required no expensive fuel while in operation, and never had to be sent to the shop for repairs. It had one serious drawback, however, in that it always insisted on fixing the conditions under which it would work. These were, that the man should first betake himself and machine to the top of a hill and fly with a downward as well as a forward motion. Unless these conditions were complied with, gravity served no better than a balky horse—it would not work at all. Although Lilienthal must have thought the conditions were rather hard, he nevertheless accepted them till something better should turn up; and in this manner he made some two thousand flights, in a few cases landing at a point more than a thousand feet distant from his place of starting. Other men, no doubt, long before had thought of trying such a plan. Lilienthal not only thought, but acted; and in so doing probably made the greatest contribution to the solution of the flying problem that has ever been made by any one man. He demonstrated the feasibility of actual practice in the air, without which success is impossible. Herr Lilienthal was followed by Mr. Pilcher, a young English engineer, and by Mr. Chanute, a distinguished member of the society I now address. A few others have built machines, but nearly all that is of real value is due to the experiments conducted under the direction of the three men just mentioned.

The balancing of a gliding or flying machine is very simple in theory. It merely consists in causing the center of pressure to coincide with the center of gravity. But in actual practice there seems to be an almost boundless incompatibility of temper which prevents their remaining peaceably together for a single instant, so that the operator, who in this case acts as peacemaker, often suffers

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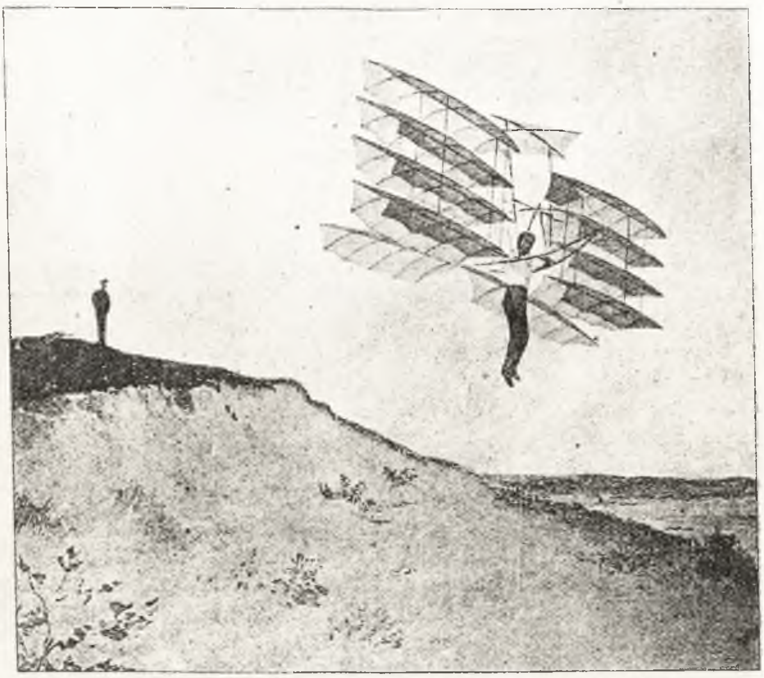
injury to himself while attempting to bring them together. If a wind strikes a vertical plane, the pressure on that part to one side of the center will exactly balance that on the other side, and the part above the center will balance that below. This point we call the center of pressure. But if the plane be slightly inclined, the pressure on the part nearest the wind is increased, and the pressure on the other part decreased, so that the center of pressure is now located, not in the center of the surface, but a little toward the side which is in advance. If the plane be still further inclined the center of pressure will move still farther forward. And if the wind blow a little to one side, it will also move over as if to meet



Chanute's Multiple-Wing Machine.

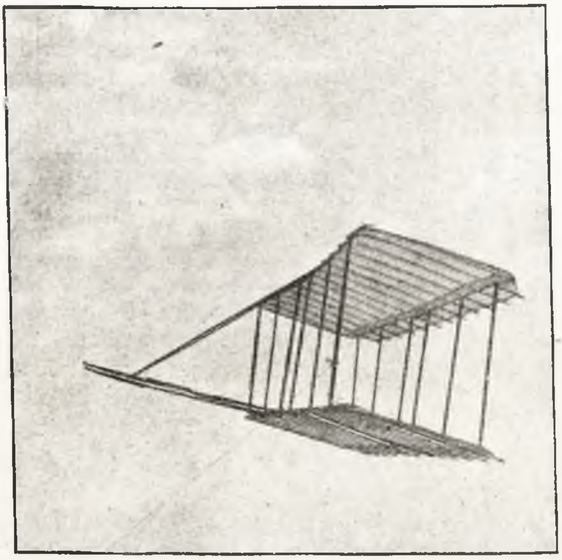
it. Now, since neither the wind nor the machine for even an instant maintains exactly the same direction and velocity, it is evident that the man who would trace the course of the center of pressure must be very quick of mind; and he who would attempt to move his body to that spot at every change must be very active indeed. Yet this is what Herr Lilienthal attempted to do, and did do with most remarkable skill, as his two thousand glides sufficiently attest. However he did not escape being overturned by wind gusts several times, and finally lost his life through a breakage of his machine, due to defective construction. The Pilcher machine was similar to that of Lilienthal, and like it, seems to have been structurally weak; for on one occasion, while exhibiting the flight of his machine to several members of the Aeronautical Society of Great Britain, it suddenly collapsed and fell to the ground, causing injuries to the operator which proved sadly fatal. The method of management of this machine differed in no important respect from that of Lilienthal, the operator shifting his body to make the centers of pressure and gravity coincide. Although the fatalities which befell the designers of these machines were due to the lack of structural strength, rather than to lack of control, nevertheless it had become clear to

Chanute's Double-Deck Machine.

the students of the problem that a more perfect method of control must be evolved. The Chanute machines marked a great advance in both respects. In the multiple wing machine, the tips folded slightly backward under the pressure of wind gusts, so that the travel of the center of pressure was thus largely counterbalanced. The guiding of the machine was done by a slight movement of the operator's body toward the direction in which it was desired that the machine should go. The double deck machine built and tried at the same time marked a very great structural advance, as it was the first in which the principles of the modern truss bridges were fully applied to flying machine construction. This machine in addition to its greatly improved construction and general design of parts also differed from the machine of Lilienthal in the operation of its tail. In the Lilienthal machine the tail, instead of being fixed in one position, was prevented by a stop from folding downward beyond a certain point, but was free to fold upward without any hindrance. In the Chanute machine the tail was at first rigid, but afterward, at the suggestion of Mr. Herring, it was held in place by a spring that allowed it to move slightly either upward or downward with reference to its normal position, thus modifying the action of the wind gusts upon it, very much to its advantage. The guiding of the machine was effected by slight movements of the operator's body, as in the multiple wing machines. Both these machines were much more manageable than the Lilienthal type, and their structural strength, notwithstanding their extreme lightness, was such that no fatalities, or even accidents, marked the glides made with them, although winds were successfully encountered much greater in violence than any which previous experimenters had dared to attempt.

My own active interest in aeronautical problems dates back to the death of Lilienthal in 1896. The brief notice of his death which appeared in the telegraphic news at that time aroused a passive interest which had existed from my childhood, and led me take down from the shelves of our home library a book on "Animal Mechanism" by Prof. Marey, which I had already read several times. From this I was led to read more modern works, and as my brother soon became equally interested with myself, we soon passed from the reading to the thinking, and finally to the working stage. It seemed to us that the main reason why the problem had remained so long unsolved was that no one had been able to obtain any adequate practice. We figured that Lilienthal in five years of time had spent only about five hours in actual gliding through the air. The wonder was not that he had done so little, but that he had accomplished so much. It would not be considered at all safe for a bicycle rider to attempt to ride through a crowded city street after only five hours practice, spread out in bits of ten seconds each over a period of five years; yet Lilienthal with this brief practice was remarkably successful in meeting the fluctuations and eddies of wind gusts. We thought that if some method could be found by which it would be possible to practice by the hour instead of by the second, there would be hope of advancing the solution of a very difficult problem. It seemed feasible to do this by building a machine which would be sustained at a speed of 18 miles per hour, and then finding a locality where winds of this velocity were common. With these conditions, a rope attached to the machine to keep it from floating backward would answer very nearly the same purpose as a propeller driven by a motor, and it would be possible to practice by the hour, and without any serious danger, as it would not be necessary to rise far from the ground, and the machine would not have any forward motion at all. We found, according to the accepted tables of air pressures on curved surfaces that a machine spreading 200 square feet of wing surface would be sufficient for our purpose, and that places could easily be found along the Atlantic coast where winds of 16 to 25 miles were not at all uncommon. When the winds were low, it was our plan to glide from the tops of sand hills, and when they were sufficiently strong, to use a rope for our motor and fly over one spot. Our next work was to draw up the plans for a suitable machine. After much study we finally concluded that tails were a source of trouble rather than of assistance; and therefore we decided to dispense with them altogether. It seemed reasonable that if the body of the operator could be placed in a horizontal position instead of the upright, as in the machines of Lilienthal, Pilcher and Chanute, the wind resistance could be very materially reduced, since only one square foot instead of five would be exposed. As a full half horse power could be saved by this change, we arranged to try at least the horizontal position. Then the method of control used by Lilienthal, which consisted in shifting the body, did not seem quite as quick or effective as the case required; so, after long study, we contrived a system consisting of two large surfaces on the Chanute double deck plan, and a smaller surface placed a short distance in front of the main surfaces in such a position that the action of the wind upon it would counterbalance the effect of the travel of the center pressure on the main surfaces. Thus changes in the direction and velocity of the wind would have little disturbing effect, and the operator would be required to attend only to the steering of the machine, which was to be affected by curving the forward surface up or down. The lateral equilibrium and the steering to right or left was to be attained by a peculiar torsion of the main surfaces, which was equivalent to presenting one end of the wings at a greater angle than the other. In the main frame a few changes were also made in the details of construction and trussing employed by Mr. Chanute. The most important of these were; (1) the moving of the forward main cross-piece of the frame to the the extreme front edge; (2) the encasing in the cloth of all cross-pieces and ribs of the surfaces; (3) a re-arrangement of the wires used in trussing the two surfaces together, which rendered it possible to tighten all the wires by simply shortening two of them.

With these plans we proceeded in the summer of 1900 to Kitty Hawk, North Carolina, a little settlement located on the strip of land that separates Albemarle Sound from the Atlantic Ocean. Owing to the impossibility of obtaining suitable material for a 200 square foot machine, we were compelled to make it only 165 square feet in area, which according to the Lilienthal tables would be supported at an angle of three degrees in a wind of about 21 miles per hour. On the very day that the machine was completed the wind blew from 25 to 30 miles per hour, and we took it out for trial as a kite. We found that while it was supported with a man on it in a wind of about 25 miles, its angle was much nearer twenty degrees than three degrees. Even in gusts of 30 miles the angle of incidence did not get as low as three degrees, although the wind at this speed has more than twice the lifting power of a 21 mile wind. As winds of 30 miles per hour are not plentiful on clear days, it was at once evident that our plan of practicing by

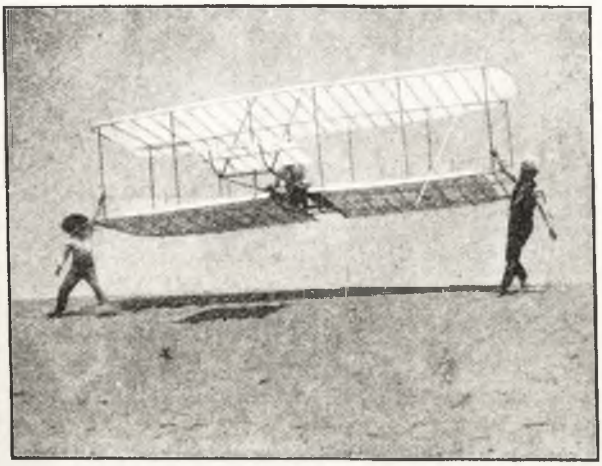


The 1900 Machine.

the hour, day after day, would have to be postponed. Our system of twisting the surfaces to regulate the lateral balance was tried and found to be much more effective than shifting the operator's body. On subsequent days, when the wind was too light to support the machine with a man on it, we tested it as a kite, working the rudders by cords reaching to the ground. The results were very satisfactory, yet we were well aware that this method of testing is never wholly convincing until the results are confirmed by actual gliding experience.

We then turned our attention to making a series of actual measurements of the lift and drift of the machine under various loads.

So far as we were aware this had never previously been done with with any full-size machine. The results obtained were most astonishing, for it appeared that the total horizontal pull of the machine, while sustaining a weight of 52 pounds, was only 8.5 lbs., which was less than had previously been estimated for head resistance of the framing alone. Making allowance for the weight carried, it appeared that the head resistance of the framing was but little more than 50 per cent of the amount which Mr. Chanute had estimated as the head resistance of the framing of his machine. On the other hand it appeared sadly deficient in lifting power as compared with the calculated lift of curved surfaces of its size. This deficiency we supposed might be due to one or more of the following causes: (1) That the depth of the curva-

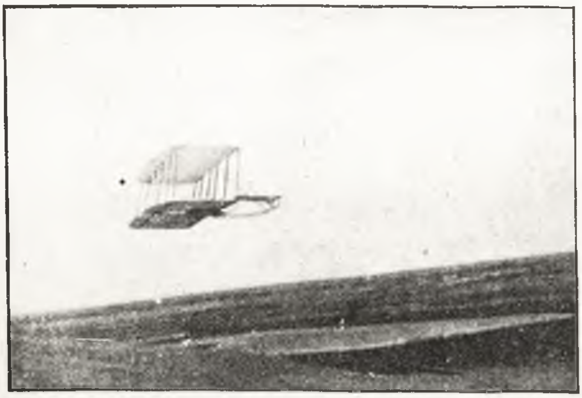


Starting a Flight.

ture of our surfaces was insufficient, being only about 1 in 22, instead of 1 in 12. (2) That the cloth used in our wings was not sufficiently air tight. (3) That the Lilienthal tables might themselves be somewhat in error. We decided to arrange our machine for the following year so that the depth of curvature of its surfaces could be varied at will, and its covering air-proofed.

Our attention was next turned to gliding, but no hill suitable for the purpose could be found near our camp at Kitty Hawk. This compelled us to take the machine to a point 4 miles south, where the Kill Devil sand hill rises from the flat sand to a height of more than 100 feet. Its main slope is toward the northeast, and has an inclination of 10 degrees. On the day of our arrival the wind blew about 25 miles an hour, and as we had had no experience at all in gliding, we deemed it unsafe to attempt to leave the ground. But on the day following, the wind having subsided to 14 miles per hour, we made about a dozen glides. It had been the original intention that the operator should run with the machine to obtain initial velocity, and assume the horizontal position only after the machine was in free flight. When it came time to land he was to resume the upright position and light on his feet, after the style of previous gliding experimenters. But on actual trial we found it much better to employ the help of two assistants in starting, which the peculiar form of our machine enabled us readily to do; and in landing we found that it was entirely practicable to land while still reclining in a horizontal position upon the machine. Although the landings were made while moving at speeds of more than 20 miles an hour, neither machine nor operator suffered any injury. The slope of the hill was 9.5 deg., or a drop of 1 foot in 6. We found that after attaining a speed of about 25 or 30 miles with reference to the wind, or 10 to 15 miles over the ground, the machine not only glided parallel to the slope of the hill, but greatly increased its speed, thus indicating its ability to glide on a somewhat less angle than 9.5 deg., when we should feel it safe to rise higher from the surface. The control of the machine proved even better than we had dared to expect, responding quickly to the slightest motion of the rudder. With these glides our experiments for the year 1900 closed. Although the hours and hours of practice we had hoped to obtain finally dwindled down to about two minutes, we were very much pleased with the general results of the trip, for setting out as we did, with almost revolutionary theories on many points, and an entirely untried form of machine, we considered it quite a point to be able to return without having our pet theories completely knocked in the head by the hard logic of experience, and our own brains dashed out in the bargain. Everything seemed to us to confirm the correctness of our original opinions, (1) that practice is the key to the secret of flying; (2) that it is practicable to assume the horizontal position, (3) that a smaller surface set at a negative angle in front of the main bearing surfaces, or wings, will largely counteract the effect of the fore and aft travel of the center of pressure, (4) that steering up and down can be attained with a rudder, without moving the position of the operator's body. (5) that twisting the wings so as to present their ends to the wind at different angles is a more prompt and efficient way of maintaining lateral equilibrium than shifting the body of the operator.

When the time came to design our new machine for 1901, we decided to make it exactly like the previous machine in theory and method of operation. But as the former machine was not able to support the weight of the operator when flown as a kite, except in very high winds and at very large angles of incidence, we decided to increase its lifting power. Accordingly, the curvature of the surfaces was increased to 1 in 12, to conform to the shape on which Lilienthal's table was based, and to be on the safe side, we decided also to increase the area of the machine from 165 square feet to 308 square feet, although so large a machine had never before been deemed controllable. The Lilienthal machine had an area of 151 square feet: that of Pilcher, 165 square feet; and the Chanute double decker, 134 square feet. As our system of control consisted in a manipulation of the surfaces themselves instead of shifting the operator's body, we hoped that the new machine

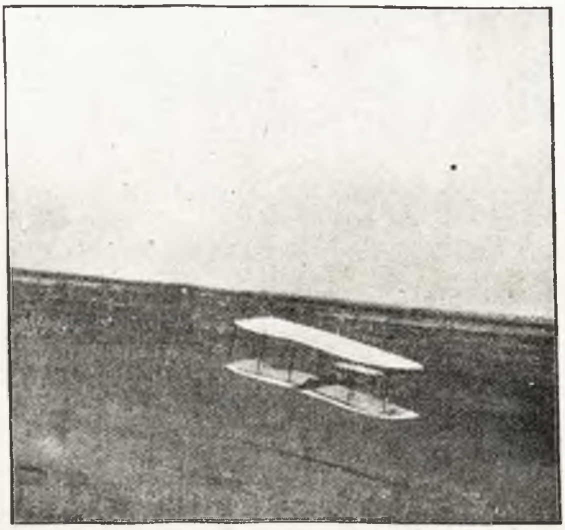


A High Glide.

would be controllable, notwithstanding its great size. According to calculations it would obtain support in a wind of 17 miles per hour with an angle of incidence of only 3 degrees.

Our experience of the previous year h ving shown the necessity of a suitable building for housing the machine, we erected a cheap frame building, 16 feet wide, 25 feet long, and 7 feet high at the eaves. As our machine was 22 feet wide, 14 feet long (including the rudder) and about 6 feet high, it was not necessary to take the machine apart in any way in order to house it. Both ends of the building, except the gable parts, were made into doors which hinged above, so that when opened they formed an awning at each end, and left an entrance the full width of the building. We went into camp about the middle of July, and were soon joined by Mr. E. C. Huffaker, of Tennessee, an experienced aeronautical investigator in the employ of Mr. Chanute, by whom his services were kindly loaned, and by Dr. G. A. Spratt, of Pennsylvania, a young man who has made some valuable investigations of the properties of variously curved surfaces and the travel of the center of pressure thereon. Early in August, Mr. Chanute came down from Chicago to witness our experiments, and spent a week in camp with us. These gentlemen, with my brother and myself, formed our camping party, but in addition we had in many of our experiments the valuable assistance of Mr. W. J. Tate and Mr. Dan. Tate, of Kitty Hawk.

The machine was completed and tried for the first time on the 27th of July in a wind blowing about 13 miles an hour. The operator having taken a position where the center of pressure was supposed to be, an attempt at gliding was made; but the machine turned downward and landed after going only a few yards. This



A Low Glide.

indicated that the center of gravity was too far in front of the center of pressure. In the second attempt the operator took a position several inches further back but the result was much the same. He kept moving further and further back with each trial, till finally he occupied a position nearly a foot back of that at which we had expected to find the center of pressure. The machine then sailed off and made an undulating flight of a little more than 300 feet. To the onlookers this flight seemed very successful, but to the operator it was known that the full power of the rudder had been required to keep the machine from either running into the ground or rising so high as to lose all headway. In the 1900 machine one-fourth as much rudder action had been sufficient to give much better control. It was apparent that something was radically wrong, though we were for some time unable to locate the trouble. In one glide the machine rose higher and higher till it lost all headway. This was the position from which Lilienthal had always found difficulty to extricate himself, as his machine then, in spite of his greatest exertions, manifested a tendency to dive downward almost vertically and strike the ground head on with frightful velocity. In this case a warning cry from the ground caused the operator to turn the rudder to its full extent and also to move his body slightly forward. The machine then settled slowly to the ground, maintaining its horizontal position almost perfectly, and landed without any injury at all. This was very encouraging, as it showed that one of the very greatest dangers in machines with horizontal tails had been overcome by the use of a front rudder. Several glides later the same experience was repeated with the same result. In the latter case the machine had even commenced to move backward, but was nevertheless brought safely to the ground in a horizontal position. On the whole, this day's experiments were encouraging, for while the action of the rudder did not seem at all like that of our 1900 machine, yet we had escaped without difficulty from positions which had proved very dangerous to preceding experimenters, and after less than one minute's actual practice had made a glide of more than 300 feet, at an angle of descent of 10 degrees, and with a machine nearly twice as large as had previously been considered safe. The trouble with its control, which has been mentioned, we believed could be corrected when we should have located its cause. Several possible explanations occurred to us, but we finally concluded that the trouble was due to a reversal of the direction of the travel of the center pressure at small angles. In deeply curved surfaces the center of pressure at 90 degrees is near the center of the surface, but moves forward as the angle becomes less, till a certain point is reached, varying with the depth of curvature. After this point is passed, the center of pressure, instead of continuing to move forward, with the decreasing angle, turns and moves rapidly toward the rear. The phenomena are due to the fact that at small angles the wind strikes the forward part of the surface on the *upper* side instead of the lower, and thus this part altogether ceases to lift, instead of being the most effective part of all, as in the case of the plane. Lilienthal had called attention to the danger of using surfaces with a curvature as great as one in eight, on account of this action on the upper side; but he seems never to have investigated the curvature and angle at which the phenomena entirely ceases. My brother and I had never made any original investigation of the matter, but assumed that a curvature of one in twelve would be safe, as this was the curvature on which Lilienthal based his tables. However, to be on the safe side, instead of using the arc of a circle, we had made the curve of our machine very abrupt at the front, so as to expose the least possible area to this downward pressure. While the machine was building, Messrs. Huffaker and Spratt had suggested that we would find this reversal of the center of pressure. but we believed it sufficiently guarded against. Accordingly, we were not at first disposed to believe that this reversal actually existed in our machine, although it

FIG. 1.

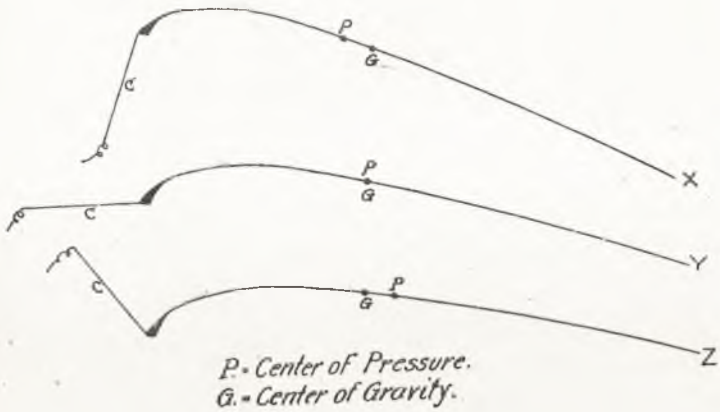


FIG. 2

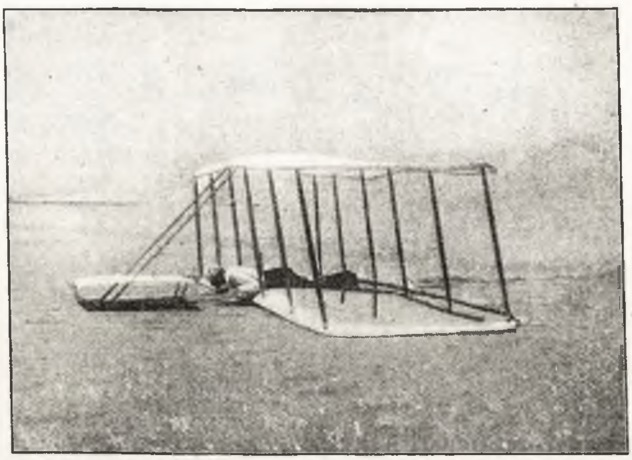
Diagrams of Pressures and Curves.

offered a perfect explanation of the action we had noticed in gliding. Our peculiar plan of control by forward surfaces, instead of tails, was based on the assumption that the center of pressure would continue to move farther and farther forward, as the angle of incidence became less, and it will be readily perceived that it would make quite a difference if the front surface instead of counteracting this assumed forward travel, should in reality be expediting an actual backward movement. For several days we were in a state of indecision, but were finally convinced by observing the following phenomena: (Figure 1) We had removed the upper surface from the machine and were flying it in a wind to see at what angles it would be supported in winds of different strengths. We noticed that in light winds it flew in the upper position shown in the figure, with a strong upward pull on the cord *c*. As the wind became stronger, the angle of incidence became less, and the surface flew in the position shown in the middle of the figure, with a slight horizontal pull. But when the wind became still stronger, it took the lower position shown in the figure, with a strong downward pull. It at once occurred to me that here was the answer to our problem, for it is evident that in the first case the center of pressure was in front of the center of gravity and thus pushed up the front edge; in the second case, they were in coincidence, and the surface in equilibrium; while in the third case the center of pressure had reached a point even behind the center of gravity, and there was therefore a downward pull on the cord. This point having been definitely settled, we proceeded to truss down the ribs of the whole machine, so as to reduce the depth of curvature. In Figure 2, line 1, shows the original curvature; line 2, the curvature when supporting the operator's weight; and line 3, the curvature after trussing.

On resuming our gliding, we found that the old conditions of the preceding year had returned; and after a few trials, made a glide of 366 feet and soon after one of 389 feet. The machine with its new curvature never failed to respond promptly to even small movements of the rudder. The operator could cause it to almost skim the ground, following the undulations of its surface, or he could cause it to sail out almost on a level with the starting point, and passing high above the foot of the hill, gradually settle down to the ground. The wind on this day was blowing 11 to 14 miles per hour. The next day, the conditions being favorable, the machine was again taken out for trial. This time the velocity of the wind was 18 to 22 miles per hour. At first we felt some doubt as to the safety of attempting free flight in so strong a wind, with a machine of over 300 square feet, and a practice of less than five minutes spent in actual flight. But after several preliminary experiments we decided to try a glide. The control of the machine seemed so good that we then felt no apprehension in sailing boldly forth. And thereafter we made glide after glide, sometimes following the ground closely, and sometimes sailing high in the air. Mr. Chanute had his camera with him, and took pictures of some of these glides, several of which are among those shown.

We made glides on subsequent days, whenever the conditions were favorable. The highest wind thus experimented in was a little over 12 meters per second—nearly 27 miles per hour.

It had been our intention when building the machine to do the larger part of the experimenting in the following manner: When the wind blew 17 miles an hour, or more, we would attach a rope to the machine and let it rise as a kite with the operator upon it. When it should reach a proper height the operator would cast off the rope and glide down to the ground just as from the top of a hill. In this way we would be saved the trouble of carrying the machine up hill after each glide, and could make at least 10 glides in the time required for 1 in the other way. But when



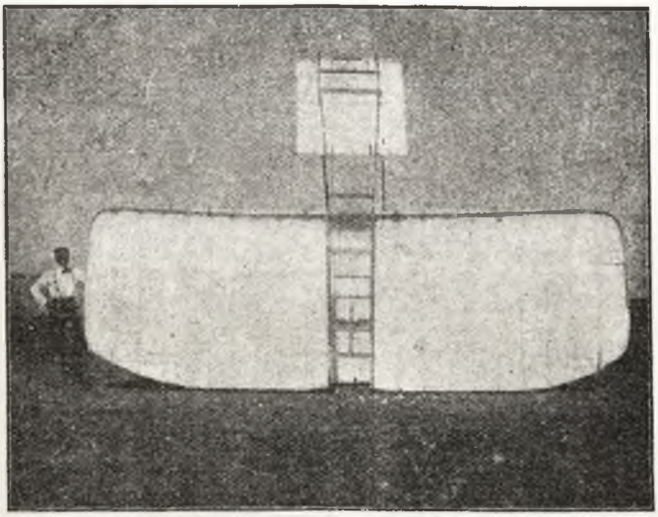
Landing.

we came to try it we found that a wind of 17 miles, as measured by Richard's anemometer, instead of sustaining the machine with its operator, a total weight of 240 lbs., at an angle of incidence of 3 degrees, in reality would not sustain the machine alone—100 pounds—at this angle. Its lifting capacity seemed searcely one-third of the calculated amount. In order to make sure that this was not due to the porosity of the cloth, we constructed two small experimental surfaces of equal size, one of which was air-proofed and the other left in its natural state; but we could detect no difference in their lifting powers. For a time we were led to suspect that the lift of curved surfaces little exceeded that of planes of the same size, but further investigation and experiment led to the opinion that (1) the anemometer used by us over-recorded the true velocity of the wind by nearly 15 per cent; (2) that the well-known Smeaton coefficient of .005 V^2 for the wind pressure at 90 degrees is probably too great by at least 20 per cent.; (3) that Lilienthal's estimate that the pressure on a curved surface having an angle of incidence of 3 degrees equals .545 of the pressure at 90 degrees is too large, being nearly 50 per cent greater than very recent experiments of our own with a special pressure testing machine indicate; (4) that the superposition of the surfaces somewhat reduced the lift per square foot, as compared with a single surface of equal area.

In gliding experiments, however, the amount of lift is of less relative importance than the ratio of lift to drift, as this alone decides the angle of gliding descent. In a plane the pressure is always perpendicular to the surface, and the ratio of lift to drift is therefore the same as that of the cosine to the sine of the angle of incidence. But in curved surfaces a very remarkable situation is found. The pressure instead of being uniformly normal to the chord of the arc, is usually inclined considerably in front of the perpendicular. The result is that the lift is greater and the drift less than if the pressure were normal. Lilienthal was the first to discover this exceedingly important fact, which is fully set forth in his book, "Bird Flight the Basis of the Flying Art," but owing to some errors in the methods he used in making measurements, question was raised by other investigators not only as to the accuracy of his figures, but even as to the existence of any tangential force at all. Our experiments confirm the existence of this force, though our measurements differ considerably from those of Lilienthal. While at Kitty Hawk we spent much time in measuring the horizontal pressure on our unloaded machine at various angles of incidence. We found that at 13 degrees the horizontal pressure was about 23 lbs. This included not only the drift proper, or horizontal component of the pressure on the side of the surface, but also the head resistance of the framing as well. The weight of the machine at the time of this test was about 108 lbs. Now, if the pressure had been normal to the chord of the surface, the drift proper would have been to the lift (108 lbs.) as the sine of 13 degrees is to the cosine of 13 degrees, or $\frac{.22 \times 108}{.97} = 24+$lbs.; but this slightly exceeds the total pull of 23 lbs. on our scales. Therefore, it is evident that the average pressure on the surface instead of being normal to the chord was so far inclined toward the front that all the head resistance of framing and wires used in the construction was more than overcome. In a wind of 14 miles per hour, resistance is by no means a negligible factor, so that tangential is evidently a force of considerable value. In a higher wind which sustained the machine at an angle of 10 degrees, the pull on the scales was 18 lbs. With the pressure normal to the chord, the drift proper would have been $\frac{.17 \times 98^*}{.98} = 17$ lbs., so that although the higher wind velocity must have caused an increase in the head resistance, the tangential force still came within one pound of overcoming it. After our return from Kitty Hawk we began a series of experiments to accurately determine the amount and direction of the pressure produced on curved surfaces when acted upon by winds at the various angles from zero to 90 degrees. These experiments are not yet concluded, but in general they support Lilienthal in the claim that the curves give pressures more favorable in amount and direction than planes; but we find marked differences in the exact values, especially at angles below 10 degrees. We were unable to obtain direct measurements of the horizontal pressures of the machine with the operator on board, but by comparing the distance traveled in gliding with the vertical fall, it was easily calculated that at a speed of 24 miles per hour the total horizontal resistances of our machine, when bearing the operator, amounted to 40 pounds, which is equivalent to about 2 1/3 horse power. It must not be supposed, however, that a motor developing this power would be sufficient to drive a man-bearing machine. The extra weight of the motor would require either a larger machine, higher speed, or a greater angle of incidence, in order to support it, and therefore more power. It is probable, however, that an engine of 6 horse power, weighing 100 hundred pounds, would answer the purpose. Such an engine is entirely practicable. Indeed, working motors of one-half this weight per horse power (9 pounds per horse power) have been constructed by several different builders. Increasing the speed of our machine from 24 to 33 miles per hour reduced the total horizontal pressure from 40 to about 35 pounds. This was quite an advantage in gliding as it made it possible to sail about 15 per cent further with a given drop. However, it would be of little or no advantage in reducing the size of the motor in a power driven machine, because the lessened thrust would be counterbalanced by the increased speed per minute. Some years ago Prof. Langley called attention to the great economy of thrust which might be obtained by using very high speeds, and from this many were led to suppose that high speed was essential to success in a motor driven machine. But the economy to which Prof. Langley called attention was in foot pounds per mile of travel, not in foot pounds per minute. It is the foot pounds per minute that fixes the size of the motor. The probability is that the first flying machines will have a relatively low speed, perhaps not much exceeding 20 miles per hour, but the problem of increasing the speed will be much simpler in some respects than that of increasing the peed of a steamboat; for, whereas in

*The travel of the center of pressure made it necessary to put sand on the front rudder to bring the centers of gravity and pressure into coincidence, consequently the weight of the machine varied from 98 lbs. to 108 lbs. in the different tests.

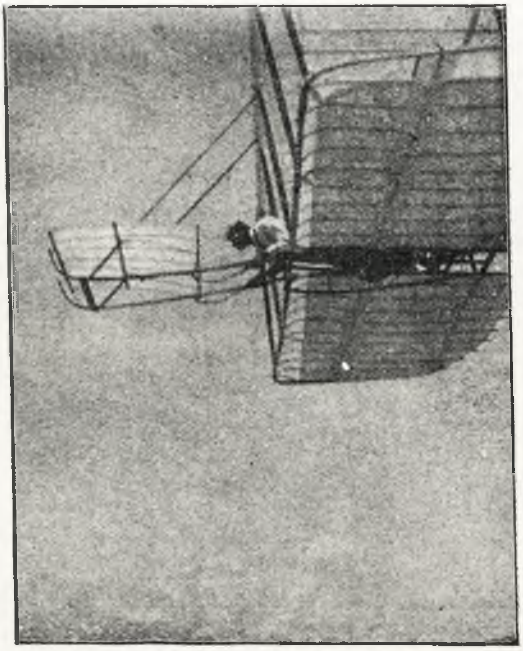
the latter case the size of the engine must increase as the cube of the speed, in the flying machine, until extremely high speeds are reached, the capacity of the motor increases in less than simple ratio; and there is even a decrease in the fuel consumption per mile of travel. In other words to double the speed of a steamship (and the same is true of the balloon type of air ship) eight times the engine and boiler capacity would be required, and four times the fuel consumption per mile of travel; while a flying machine would require engines of less than double the size, and there would be an actual decrease in the fuel consumption per mile of travel. But looking at the matter conversely, the great disadvantage of the flying machine is apparent; for in the latter no flight at all is possible unless the proportion of horse power to flying capacity is very high;



A Bottom View.

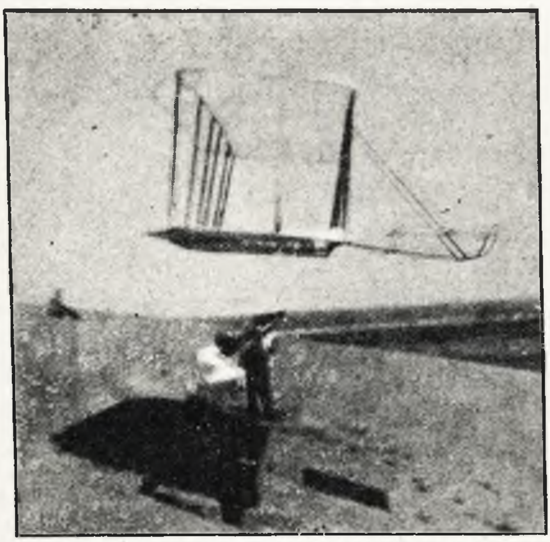
but on the other hand a steamship is a mechanical success if its ratio of horsepower to tonnage is insignificant. A flying machine that would fly at a speed of 50 miles an hour with engines of 1,000 horse power, would not be upheld by its wings at all at a speed of less than 25 miles an hour, and nothing less than 500 horse power could drive it at this speed. But a boat which could make 40 miles per hour with engines of 1,000 horse power, would still move 4 miles an hour even if the engines were reduced to 1 horse power. The problems of land and water travel were solved in the 19th century because it was possible to begin with small achievements and gradually work up to our present success. The flying problem was left over to the 20th century, because in this case the art must be highly developed before any flight of any considerable duration at all can be obtained.

However, there is another way of flying which requires no artificial motor, and many workers believe that success will first come by this road. I refer to the soaring flight, by which the machine is permanently sustained in the air by the same means that are employed by soaring birds. They spread their wings to the wind, and sail by the hour, with no perceptible exertion beyond that required to balance and steer themselves. What sustains them is not definitely known, though it is almost certain that it is a rising current of air. But whether it be a rising current or something else, it is as well able to support a flying machine as a bird, if man once learns the art of utilizing it. In gliding experiments it has long been known that the rate of vertical descent is very much retarded and the duration of the flight greatly prolonged, if a strong wind blows *up* the face of the hill parallel to its surface. Our machine, when gliding in still air, has a rate of vertical descent of nearly 6 feet per second, while in a wind blowing 26 miles per hour up a steep hill, we made glides in which the rate of descent was less than 2 feet per second. And during the larger part of this time, while the machine remained



Soaring.

exactly in the rising current, *there was no descent at all, but even a slight rise.* If the operator had had sufficient skill to keep himself from passing beyond the rising current, he would have been sustained indefinitely at a higher point than that from which he started. The illustration shows one of these very slow glides at a time when the machine was practically at a standstill. The failure to advance more rapidly caused the photographer some trouble in aiming, as you will perceive. In looking at this picture you will readily understand that the excitement of gliding experiments does not entirely cease with the breaking up of camp. In the photographic dark room at home we pass moments of as thrilling interest as any in the field, when the image begins to appear on the plate and it is yet an open question whether we have a picture of a flying machine, or merely a patch of open sky. These slow glides in rising currents probably hold out greater hope of extensive practice than any other method within man's reach, but they have the disadvantage of requiring rather strong winds or very large supporting surfaces. However, when gliding operators have attained greater skill, they can, with comparative safety, maintain themselves in the air for hours at a time in this way, and thus by constant practice so increase their knowledge and skill that they can rise into the higher air and search out the currents which enable the soaring birds to transport themselves to any desired point by first rising in a circle and then sailing off at a descending angle. This illustration



Ki e Soaring.

shows the machine, alone, flying in a wind of 35 miles per hour on the face of a steep hill, 100 feet high. It will be seen that the machine not only pulls upward, but also pulls forward in the direction from which the wind blows, thus overcoming both gravity and the speed of the wind. We tried the same experiment with a man on it, but found danger that the forward pull would become so strong that the men holding the ropes would be dragged from their insecure foothold on the slope of the hill. So this form of experimenting was discontinued after four or five minutes' trial.

In looking over our experiments of the past two years, with models and full size machines, the following points stand out with clearness:

1. That the lifting power of a large machine, held stationary in a wind at a small distance from the earth, is much less than the Lilienthal table and our own laboratory experiments would lead us to expect. When the machine is moved through the air, as in gliding, the discrepancy seems much less marked.

2. That the ratio of drift to lift in well shaped surfaces is less at angles of incidence of 5 deg. to 12 deg. than at an angle of 3 deg.

3. That in arched surfaces the center of pressure at 90 deg. is near the center of the surface, but moves slowly forward as the angle becomes less, till a critical angle varying with the shape and depth of the curve is reached, after which it moves rapidly toward the rear till the angle of no lift is found.

4. That with similar conditions, large surfaces may be controlled with not much greater difficulty than small ones, if the control is effected by manipulation of the surfaces themselves, rather than by a movement of the body of the operator.

5. That the head resistances of the framing can be brought to a point much below that usually estimated as necessary.

6. That tails, both vertical and horizontal, may with safety be eliminated in gliding and other flying experiments.

7. That a horizontal position of the operator's body may be assumed without excessive danger, and thus the head resistance reduced to about one-fifth that of the upright position.

8. That a pair of superposed, or tandem surfaces, has less lift in proportion to drift than either surface separately, even after making allowance for weight and head resistance of the connections.

DEFENDANTS' EXHIBIT "WRIGHT 1903 ADDRESS"

EXPERIMENTS AND OBSERVATIONS IN SOARING FLIGHT.

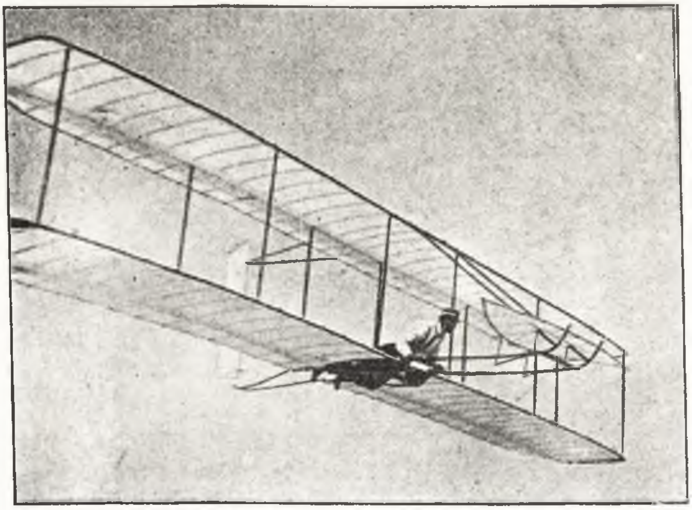
By Mr. Wilbur Wright, Dayton, Ohio.

Read June 24, 1903.

In the address which I delivered before this society in September, 1901, some account was given of the gliding experiments made by my brother, Orville Wright, and myself in the years 1900 and 1901. Afterward laboratory experiments were undertaken for the purpose of determining for ourselves the amount and direction of the pressures produced by the wind upon plane and arched surfaces exposed at various angles of incidence. The results having indicated the possibility of a gliding machine capable of much better performance than any previously built by us, we set about designing a new one for the 1902 season, and in August repaired to our old camp at the Kill Devil hills. We found that in our absence the wind had blown the sand from under the ends of our building and let them down fully two feet, so that after a rain the floor was covered with water to a depth of about twenty inches. We, therefore, proceeded to raise the building to its former level, and built a small addition to make it large enough to house the new machine.

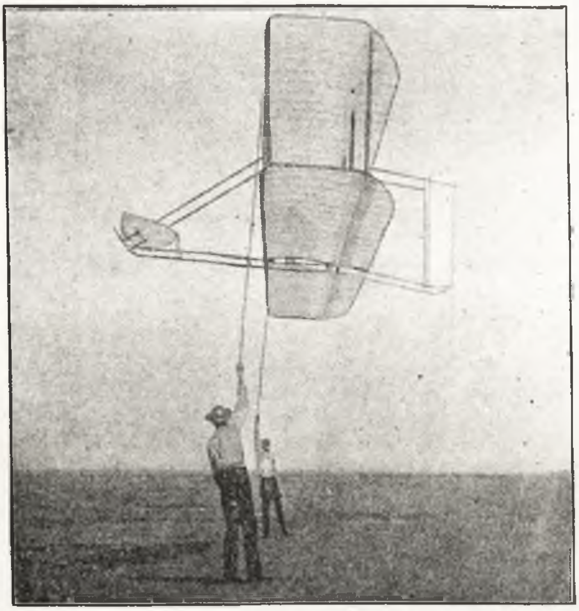
The 1902 pattern was a double deck machine having two surfaces each 32 feet from tip to tip, and 5 feet from front to rear. The total area of the main surfaces was about 305 square feet. The front rudder spread 15 square feet additional, and the vertical tail about 12 square feet, which was subsequently reduced to 6 square feet. The weight was 116½ lbs. Including the operator, the total weight was from 250 to 260 lbs. It was built to withstand hard usage, and in nearly a thousand glides was injured but once. It repeatedly withstood without damage the immense strains arising from landing at full speed in a slight hollow where only the tips of the wings touched the earth, the entire weight of machine and operator being suspended between.

The practice ground at the Kill Devil hills consists of a level plain of bare sand, from which rises a group of detached hills or mounds formed of sand heaped up by the winds. These hills are constantly changing in height and slope, according to the direction and force of the prevailing winds. The three which we use for gliding experiments are known as the Big Hill, the Little Hill and the West Hill, and have heights of 100 feet, 30 feet and 60 feet, respectively. In accordance with our custom of beginning opera-



At Close Range.

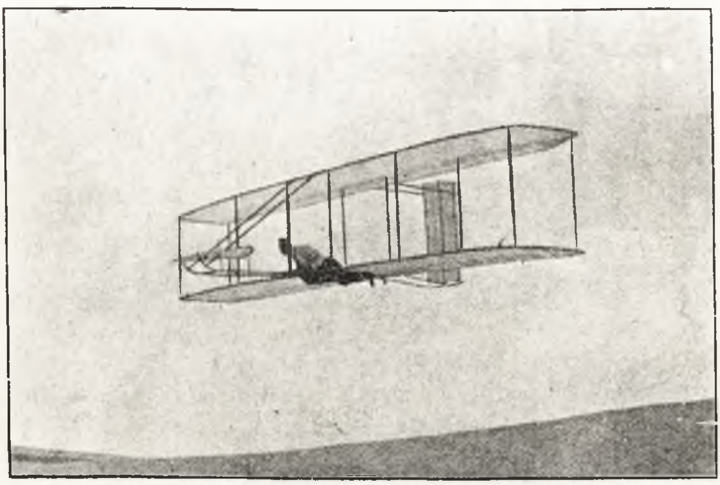
tions with the greatest possible caution, we selected the Little Hill as the field of our first experiments, and began by flying the machine as a kite. The object of this was to determine whether or not it would be capable of soaring in a wind having an upward trend of a trifle over 7 degrees, which was the slope of the hill up which the current was flowing. When I speak of soaring, I mean not only that the weight of the machine is fully sustained, but also that the direction of the pressure upon the wings is such that the propelling and the retarding forces are exactly in balance; in other words, the resultant of all the pressures is exactly vertical, and therefore without any unbalanced horizontal component. A kite is soaring when the string stands exactly vertical, this showing that there is no backward pull. The phenomenon is exhibited only when the kite is flown in a rising current of air. In principle soaring is exactly equivalent to gliding, the practical difference being that in one case the wind moves with an upward trend against a motionless surface, while in the other the surface moves with a downward trend against motionless air. The reactions are identical. The soaring of birds consists in gliding downwards through a rising current of air which has a rate of ascent equal to the bird's relative rate of descent. Testing a gliding machine as a kite on a suitable slope, with just enough wind to sustain the machine at its most favorable angle of incidence, is one of the most satisfactory methods of determining its efficiency. In soaring, the kite must fly steadily with the string vertical or a little to the front. Merely darting up to this position for an instant is not soaring. On trial we found that the machine would soar on the side of a hill having a slope of about 7 degrees, whenever the wind was of proper force to keep the angle of incidence between 4 and 8 degrees. If the wind became too strong or too weak the ropes would incline to leeward. The picture was taken when the wind was too weak for real soaring. The surfaces are inclined 4 degrees above the horizon, which is marked by the ocean level in the distance.



Kite Flying.

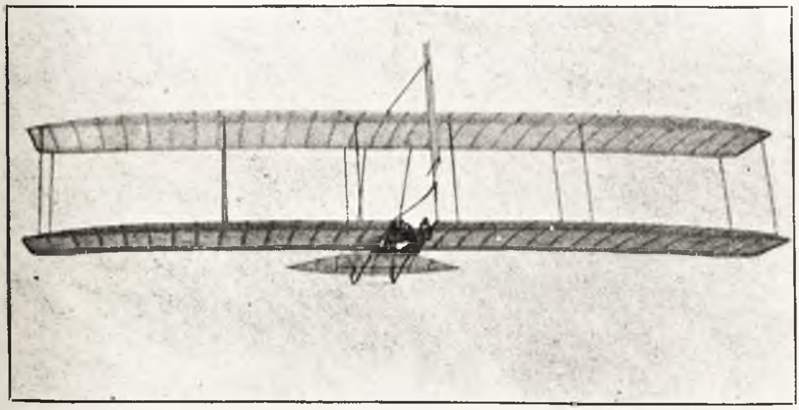
Since the wind had an upward trend of 7 degrees, the total angle of incidence was 11 degrees, which is outside the limits specified. On steeper slopes the ropes inclined to windward quite strongly. In experimenting on this plan, it is essential that a uniform slope be found which will give the air current a rising trend just sufficient to cause the kite string to stand vertical. Then both gravity and the pull on the string, which together provide the force counteracting the wind pressure on the surfaces, are applied in a single direction. It is therefore not material what proportion of the total counteracting force is due to each of the several components, nor even what is their total amount, because the experiment is exclusively for the purpose of determining the direction of the pressure on the surfaces by observing the direction of the reaction. When the kite string inclines to windward the slope is too steep, if to leeward not steep enough. But it is not advisable to attempt to determine how much the slope varies from the proper amount by observing the angle of the string from the vertical, for when the pull of the string differs in direction from that of gravity it becomes necessary to know not only the angle but also the exact amount of the pull and the proportion which it bears to the weight of the kite. It is therefore advisable to hunt a better slope rather than attempt to make so many observations.

The kite experiments having shown that it ought to be possible to glide on the 7-degree slope, we next proceeded to try it. Although on this first day it was not considered advisable to venture upon any absolutely free flights, the machine soon demonstrated its ability to glide with this angle of descent. At a later period we made more than a hundred flights the full length of this slope and landed a short distance out on the level ground. On the second day the machine was taken to the Big Hill and regular gliding was commenced. The wind was somewhat brisk. In one flight the wind struck the machine from the left and began lifting the left wing in



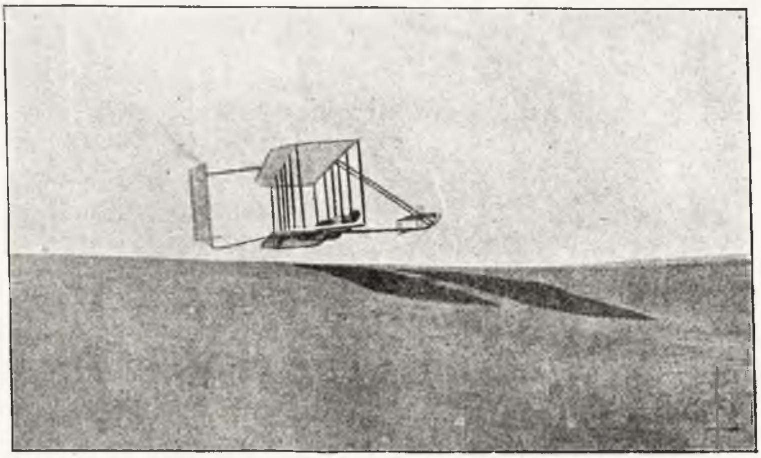
A Glide with Double Tail Machine.

a decidedly alarming manner. Owing to the fact that in the new machine changes had been made in the mechanisms operating the rudders, so that the movements were exactly reversed, it was necessary to think a moment before proceeding to make the proper adjustment. But meanwhile the left wing was rising higher and higher. I therefore decided to bring the machine to the ground as quickly as possible, but in my confusion forgot the change that had been made in the front rudder and instinctively turned it the wrong way. Almost instantly it reared up as though bent on a mad attempt to pierce the heavens. But after a moment it seemed to perceive the folly of such an undertaking and gradually slowed up till it came almost to a stop with the front of the machine still pointing heavenward. By this time I had recovered myself and reversed the rudder to its full extent, at the same time climbing upward toward the front so as to bring my weight to bear on the part that was too high. Under this heroic treatment the machine turned downward and soon began to gather headway again. By the time the ground was reached it was under fair control, but as one wing touched first it swung around in landing and came to rest with the wind blowing in from the rear. There was no unusual shock in landing and no damage at all resulted. In several other glides there were disturbances of the lateral equilibrium more marked than we had been accustomed to experience with the former machines, and we were at a loss to know what the cause might be. The new machine had a much greater tip-to-tip dimension than our former machines; it also had a vertical tail while the earlier ones were tailless; and the wing tips were on a line with the center while the old machines had the tips drawn down like a



View from the Rear.

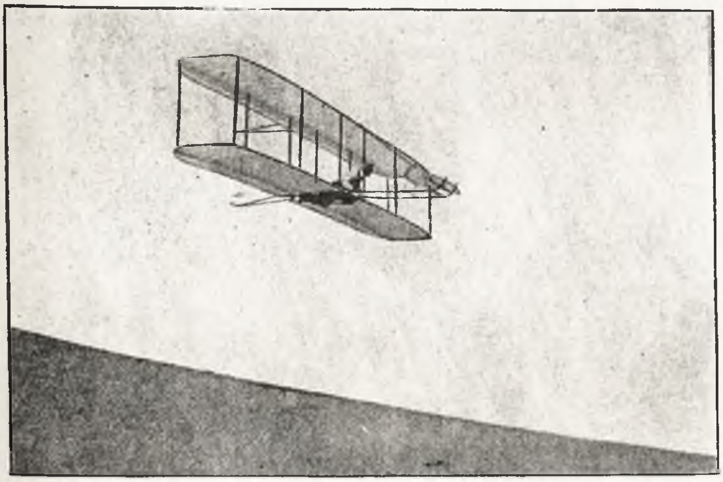
gull's wings. The trouble might be due to either of these differences. We decided to begin alterations at the wing tips, and the next day made the necessary changes in the trussing, thus bringing the tips six inches lower than the center. For several days thereafter the weather was not suitable for gliding on account of rain, but finally the sky cleared and the machine was taken out again. As the anemometer indicated a wind velocity of more than 11 meters a second, it was thought best to make use of the Little Hill in testing the effect of the changes that had been made. But later in the day, when the velocity fell to about nine meters a second, the Big Hill was tried again. On this day my brother Orville did most of the gliding. After a few preliminary flights to accustom himself to the new method of operating the front rudder, he felt himself ready to undertake the management of the lateral control also. Shortly afterward he started on a flight with one wing slightly higher than the other. This caused the machine to veer to the left. He waited a moment to see whether it would right itself, but finding that it did not, then decided to apply the control. At the very instant he did this, however, the right wing most unexpectedly raised much worse than before and led him to think that possibly he had made a mistake. A moment of thought was required to assure himself that he had made the right motion, and another to increase the movement. Meanwhile he had neglected the front rudder by which the fore and aft balance was maintained. The machine turned up in front more and more till it assumed a most dangerous attitude. We who were on the ground noticed this in advance of the aviator, who was thoroughly absorbed in the attempt to restore the lateral balance, but our shouts of alarm were drowned by the howling of the wind. It was only when the machine came to a stop and started backward that he at length realized the true situation. From the height of nearly thirty feet the machine sailed diagonally backward till it struck the ground. The unlucky aeronaut had time for one hasty glance behind him and the next instant found himself the center of a mass of fluttering wreckage. How he escaped injury I do not know, but afterward he was unable to show a scratch or bruise anywhere, though his clothes were torn in one place. This little misadventure which occurred almost at the very begin-



Skimming the Ground.

ning of our practice with the new machine was the only thing approaching an accident that happened during these experiments, and was the only occasion on which the machine suffered any injury. The latter was made as good as new by a few days' labor, and was not again broken in any of the many hundred glides which we subsequently made with it. By long practice the management of a flying machine should become as instinctive as the balancing movements a man unconsciously employs with every step in walking, but in the early days it is easy to make blunders. For the purpose of reducing the danger to the lowest possible point we usually kept close to the ground. Often a glide of several hundred feet would be made at a height of a few feet or even a few inches sometimes. It was the aim to avoid unnecessary risk. While the high flights were more spectacular, the low ones were fully as valuable for training purposes. Skill comes by the constant repetition of familiar feats rather than by a few over-bold attempts at feats for which the performer is yet poorly prepared.

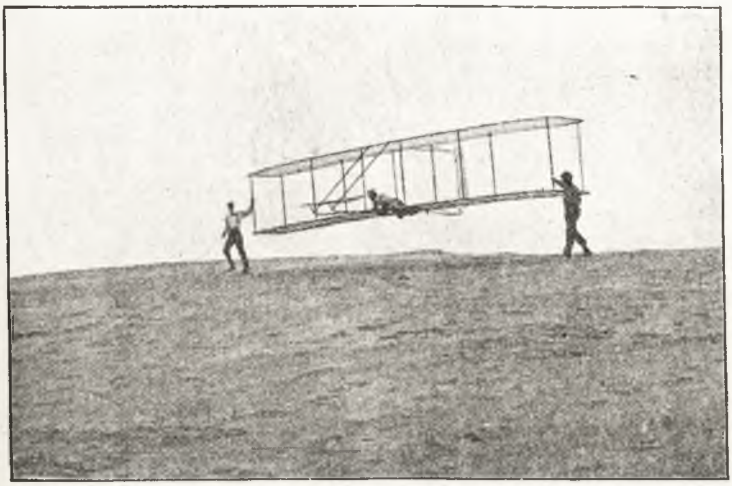
It had been noticed during the day that when a side gust struck the machine its effect was at first partly counteracted by the vertical tail, but after a time when the machine had acquired a lateral motion, the tail made matters worse instead of better. Although the change that had been made in the wing tips made some improvement, the lateral control still remained somewhat unsatisfactory. The tail was useful at times and at others was seriously in the way. It was finally concluded that the best way of overcoming the difficulty was by making the tail movable like a rudder. As originally built the fixed vertical tail or vane was double, but in changing to a movable rudder it was made single, as the smaller area was believed to be



A Good Flight.

sufficient. As reconstructed it spread a little less than six square feet. With this improvement our serious troubles ended and thereafter we devoted ourselves to the work of gaining skill by continued practice. When properly applied the means of control proved to possess a mastery over the forces tending to disturb the equilibrium. Since balancing was effected by adjustments of the surfaces, instead of by movements of weight, the controlling forces increased in power in the same ratio as the disturbing forces, when the machine was suddenly struck by a wind gust. For this reason we did not seem to experience the same difficulty in managing the machine in high winds, that Lilienthal who used a different system seems to have met. Fully half of our glides were made in winds of 10 meters a second, over 20 miles an hour. One day we stopped gliding for a moment to take an anemometer reading and found that it indicated 16.7 meters a second, 37 miles an hour. Of course such high winds require much greater readiness on the part of the operator than the low winds, since everything happens much more quickly, but otherwise the difference is not so very marked. In those machines which are controlled by the shifting of weight, the disturbing influences increase as the square of the velocity, while the controlling factor remains a constant quantity. For this reason a limit to the wind velocity which it is possible to safely encounter with such machines is soon reached, regardless of the skill of the operator. With the method we have been using the capacity of control is evidently very great. The machine seems to have reached a higher state of development than the operators. As yet we consider ourselves little more than novices in management. A thousand glides is equivalent to about four hours of steady practice, far too little to give anyone a complete mastery of the art of flying. Progress is very slow in the preliminary stages, but when once it becomes possible to undertake continuous soaring advancement should be rapid. Under special conditions it is possible that this point is not so far away as might be supposed. Since soaring is merely gliding in a rising current it would be easy to soar in front of any hill of suitable slope, whenever the wind blew with sufficient force to furnish support, provided the wind were steady. But by reason of changes in wind velocity there is more support at times than is needed, while at others there is too little, so that a considerable degree of skill, experience and sound judgment is required in order to keep the machine exactly in the rising current. So far our only attempts at soaring have been made on the Little Hill, which has a slope of only seven degrees. In a wind blowing from 11 to 16 meters a second, we frequently made glides of 8 to 15 seconds' duration with very little forward motion. As we kept within five or six feet of the ground, a momentary lessening of the wind speed, or a slight error in management, was sufficient to bring about a landing in a short time. The wind had too little rising trend to make soaring easy. The buzzards themselves were balked when they attempted to soar on this hill, as we observed more than once. It would be well within the power of the machine to soar on the Big Hill, which has steeper slopes, but we have not felt that our few hours of practice is sufficient to justify ambitious attempts too hastily. Before trying to rise to any dangerous height a man ought to know that in an emergency his mind and muscles will work by instinct rather than by conscious effort. There is no time to think.

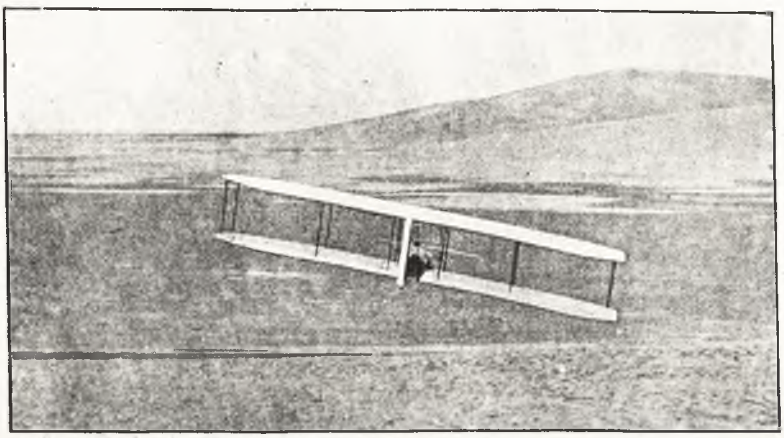
During a period of five weeks glides were made whenever the



Starting a Flight.

weather conditions were favorable. Many days were lost on account of rain. Still more were lost on account of light winds. Whenever the breeze fell below six miles an hour, very hard running was required to get the machine started, and the task of carrying it back up the hill was real labor. A relative speed of at least 18 miles an hour was required for gliding, while to obtain a speed of 12 miles by running required very severe exertion. Consequently unless the wind blew in our faces with a speed of at least six miles we did not usually attempt to practice; but when the wind rose to 20 miles an hour, gliding was real sport, for starting was easy and the labor of carrying the machine back up hill was performed by the wind. On the day when the wind rose to over 16 meters a second we made more than a hundred glides with much less physical exhaustion than resulted from twenty or thirty glides on days when the wind was light. No complete record was kept of all the glides made during the season. In the last six days of experiment we made more than 375, but these included our very best days. The total number for the season was probably between 700 and 1,000. The longest glide was 622½ feet, and the time 26 seconds.

The prime object in these experiments was to obtain practice in the management of a man-carrying machine, but an object of



This shows method of [illegible] turning.

Turning to the Right.

scarcely less importance was to obtain data for the study of the scientific problems involved in flight. Observations were almost constantly being made for the purpose of determining the amount and direction of the pressures upon the sustaining wings; the minimum speed required for support; the speed and angle of incidence at which the horizontal resistance became least; and the minimum angle of descent at which it was possible to glide. To determine any of these points with exactness was found to be very difficult indeed, but by careful observations under test conditions it was possible to obtain reasonably close approximations. It was found that a speed of about sixteen miles an hour would produce a pressure sufficient to support machine and operator, but the angle of incidence was too great for general gliding purposes. At eighteen miles the angle of incidence was about eight degrees, and the machine would glide on the Little Hill, descending at an angle of a little over seven degrees. Although the wings were inclined slightly above the horizon the machine continued to glide without loss of velocity. With a speed of 22 miles an hour, the angle of incidence required for support was four or five degrees, and the angle of descent a little less than seven degrees. At this speed the surfaces were inclined several degrees below the horizon. As the speed became greater the angle of incidence continued to grow less, but the angle of descent became greater again, thus showing that the point of minimum resistance had been passed. Scores of glides were made at angles of descent under six degrees, and in a few cases we reached five degrees. On the last day of experiment we made a few attempts at records. A line was drawn a short distance up the slope as a starting mark, and four trials were made. Twice the machine landed on the same spot. The distance was 156½ feet, and the angle of descent exactly five degrees. Time, 6½ seconds. From a point higher up the slope the best angle was 5 degrees and 25 minutes, for a glide of 225 feet. Time, 10¼ seconds. The wind was blowing about nine miles an hour. The glides were made directly to windward and straight down the slope. Taking seven degrees as a conservative estimate of the normal angle of descent, the horizontal resistance of the machine was 30 pounds, as computed by multiplying the total weight, 250 pounds, by the tangent of the angle of descent. This resistance remained nearly constant at speeds between 18 and 25 miles an hour. Above or below these limits there was a somewhat rapid increase. At 18 miles the power consumed was one and one-half horse-power; at 25 miles, two horse-power. At the slower speed, 166 pounds were sustained for each horse-power consumed; at the higher speed, 125 pounds per horse-power. Between 18 and 25 miles the horse-power increased almost in exact ratio to the increase in speed, but above or below these limits the power increased rapidly, and with a constantly accelerating ratio.

On two occasions we observed a phenomenon whose nature we were not able to determine with certainty. One day my brother noticed in several glides a peculiar tapping as if some part of the machine were loose and flapping. Careful examination failed to disclose anything about the machine which could possibly cause it. Some weeks later, while I was making a glide, the same peculiar tapping began again in the midst of a wind gust. It felt like little waves striking the bottom of a flat bottomed row-boat. While I was wondering what the cause could be, the machine suddenly, but without any noticeable change in its inclination to the horizon, dropped a distance of nearly ten feet, and in the twinkling of an eye was flat on the ground. I am certain that the gust went out with a downward trend which struck the surfaces on the upper side. The descent was at first more rapid than that due to gravity, for my body apparently rose off the machine till only my hands and feet touched it. Toward the end the descent was slower. It may be that the tapping was caused by the wind rapidly striking the surfaces alternately on the upper and the lower sides. It is a rule almost universal that gusts come on with a rising trend and die out with a descending trend, but on these particular occasions there must have been a most unusual turmoil during the continuance of the gust which would have exhibited a very interesting spectacle had it been visible to the eye. Irregularities of the wind are most noticeable when the wind is high, on account of the greater power then exhibited, but light winds show almost equal relative variations. An aviator must expect to encounter in every flight variations in velocity, in direction, and in upward or downward trend. And these variations not only give rise to those disturbances of the equilibrium which result from the travel of the center of pressure due to the changed angle of incidence, but also, by reason of the fact that the wind changes do not occur simultaneously or uniformly over the entire machine, give rise to a second series of disturbances of even more troublesome character. Thus a gust coming on very suddenly will strike the front of the machine and throw it up before the back part is acted upon at all. Or the right wing may encounter a wind of very different velocity and trend from the left wing and the machine will tend to turn over sidewise. The problem of overcoming these disturbances by automatic means has engaged the attention of many very ingenious minds, but to my brother and myself it has seemed preferable to depend entirely on intelligent control. In all of our machines the maintenance of the equilibrium has been dependent on the skill and constant vigilance of the aviators.

In addition to the work with the machine we also made many observations on the flight of soaring birds, which were very abundant in the vicinity of our camp. Bald eagles, ospreys, hawks and buzzards gave us daily exhibitions of their powers. The buzzards were the most numerous and were the most persistent soarers. They apparently never flapped except when it was absolutely necessary, while the eagles and hawks usually soared only when they were at leisure. Two methods of soaring were employed. When the weather was cold and damp and the wind strong, the buzzards would be seen soaring back and forth along the hills or at the edge of a clump of trees. They were evidently taking advantage of the current of air flowing upward over these obstructions. On such days they were often utterly unable to soar except in these special places. But on warm clear days when the wind was light they would be seen high in the air soaring in great circles. Usually however it seemed to be necessary to reach a height of several hundred feet by flapping before this style of soaring became possible. Frequently a great number of them would begin circling in one spot, rising together higher and higher till finally they would disperse, each gliding off in whatever direction it wished to go. At such times other buzzards only a short distance away found it necessary to flap frequently in order to maintain themselves. But when they reached a point beneath the circling flock they too began to rise on motionless wings. This seemed to indicate that rising columns of air do not exist everywhere, but that the birds must find them. They evidently watch each other and when one finds a rising current the others quickly make their way to it. One day when scarce a breath of wind was stirring on the ground, we noticed two bald eagles sailing in circling sweeps at a height of probably 500 feet. After a time our attention was attracted to the flashing of some object considerably lower down. Examination with a field glass proved it to be a feather which one of the birds had evidently cast. As it seemed apparent that it would come to earth only a short distance away some of our party started to get it. But in a little while it was noticed that the feather was no longer falling but on the contrary was rising rapidly. It finally went out of sight upward. It apparently was drawn into the same rising current in which the eagles were soaring, and was carried up like the birds.

The days when the wind blew horizontally gave us the most satisfactory observations, as then the birds were compelled to make use of the currents flowing up the sides of the hills and it was possible for us to measure the velocity and trend of the wind in which the soaring was performed. One day four buzzards began soaring on the northeast slope of the Big Hill at a height of only ten or twelve feet from the surface. We took a position to windward and about 1,200 feet distant. The clinometer showed that they were 4½ to 5½ degrees above our horizon. We could see them very distinctly with a field glass. When facing us the under side of their wings made a broad band on the sky, but when in circling they faced from us we could no longer see the under side of their wings. Though the wings then made little more than a line on the sky the glass showed clearly that it was not the under side that we saw. It was evident that the buzzards were soaring with their wings constantly inclined about five degrees above the horizon. They were attempting to gain sufficient altitude to enable them to glide to the ocean beach three-fourths of a mile distant, but after reaching a height of about 75 feet above the top of the hill they seemed to be unable to rise higher, though they tried a long time. At last they started to glide toward the ocean but were compelled to begin flapping almost immediately. We at once measured the slope and the wind. The former was 12½ degrees; the latter was six to eight meters per second. Since the wings were inclined 5 degrees above the horizon and the wind had a rising trend of fully 12 degrees, the angle of incidence was about 17 degrees. The wind did not average more than seven meters, 15 miles an hour. For the most part the birds faced the wind steadily, but in the lulls they were compelled to circle or glide back and forth in order to obtain speed sufficient to provide support. As the buzzard weighs about .8 pounds per square foot of wing area, the lifting power of the wind at 17 degrees angle of incidence was apparently as great as it would have been had it been blowing straight upward with equal velocity. The pressure was inclined 5 degrees in front of the normal, and the angle of descent was 12½ degrees.

On another day I stood on top of the West Hill directly behind a buzzard which was soaring on the steep southern slope. It was just on a level with my eye and not more than 75 feet distant. For some time it remained almost motionless. Although the wings were inclined about five degrees above the horizon, it was not driven backward by the wind. This bird is specially adapted to soaring at large angles of incidence in strongly rising currents. Its wings are deeply curved. Unless the upward trend amounts to at least eight degrees it seems to be unable to maintain itself. One day we watched a flock attempting to soar on the west slope of the Big Hill, which has a descent of nearly nine degrees. The birds would start near the top and glide down along the slope very much as we did with the machine, but we noticed that whenever they glided parallel with the slope their speed diminished, and when their speed was maintained the angle of descent was greater than that of the hill. In every case they found it necessary to flap before they had gone two hundred feet. They tried time and again but always with the same results. Finally they resorted to hard flapping till a height of about 150 feet above the top of the hill was reached, after which they were able to soar in circles without difficulty. On another day they finally succeeded in rising on almost the same slope, from which it was concluded that the buzzard's best angle of descent could not be far from eight degrees. There is no question in my mind that men can build wings having as little or less relative resistance than that of the best soaring birds. The bird's wings are undoubtedly very well designed indeed, but it is not any extraordinary efficiency that strikes with astonishment but rather the marvelous skill with which they are used. It is true that I have seen birds perform soaring feats of almost incredible nature in positions where it was not possible to measure the speed and trend of the wind, but whenever it was possible to determine by actual measurement the conditions under which the soaring was performed, it was easy to account for it on the basis of the results obtained with artificial wings. The soaring problem is apparently not so much one of better wings as of better operators.

DISCUSSION.

Mr. Chanute—Mr. Wright has advised you heretofore as to the advance made by others, but he has not advised you of the advance achieved by his recent experiments.

As regards the weight sustained per horse-power, which will perhaps strike you as being very small in comparison with the weights that are propelled either upon the land or water, you may remember that the machine experimented with by Mr. Maxim sustained only 28 pounds to the horse-power, and that the model experimented with in 1896, by Prof. Langley sustained only 31 pounds to the horse-power, while the machine experimented with by the Messrs. Wright sustains 165 pounds to the horse-power. It is true that a large deduction must be made from those figures when a motor is applied, but nevertheless they constitute a very great advance. Moreover, it is only when support is obtained at flat angles of gliding advance, that we may hope to apply power successfully and to fly through the air. The best experiments which I had been able to make in 1896 were to obtain angles of descent of 7½ to 11 degrees. Mr. Wright has been enabled to obtain angles of descent of 6 to 7 degrees, and in one case, as he has told you, a descent of only 5 degrees. This constitutes a very great progress and gives out a good hope of further advance hereafter.

I presume that some of you may desire to ask some questions of Mr. Wright, which I am sure he will be very glad to answer. The paper is now open for discussion.

Mr. Churchill—Is it true that, according to your results, to propel an airship by means of a motor or other means of propulsion, horizontally, the wings would have to be inclined about 17 degrees? That is to say, the angle would be 5 degrees plus 12½ degrees, as in the case of the buzzard?

Mr. Wright—No, that was simply an example of soaring. If it were desired to fly by mechanical means horizontally through the air, the best angle would be about 5 to 7 degrees; that is, the wings should be set probably in the neighborhood of 5 to 7 degrees above the horizon. In our machine the weight was about 250 to 260 pounds, on a little over 300 square feet area of the main surfaces—about .8 pound to the square foot—and we found that with a speed of 25 miles per hour the wings only had to be inclined about 3 or 3½ degrees.

Mr. Bainbridge—Do you think it is impossible for a bird to soar in a horizontal wind?

Mr. Wright—I do not think any bird soars in a horizontal wind. In order to soar it is necessary that the resultant of all the pressures produced by the relative wind be exactly vertical, but in a horizontal wind this pressure is always inclined at least 6 degrees backward from the vertical. It therefore has a horizontal component which would cause the bird to drift with the wind until the relative speed required for support was entirely lost. It is only in a rising trend of wind that the bird can obtain propelling forces to balance the drift and thus make the resultant of all the pressures vertical.

Mr. Warder—I would like to ask in regard to the covering and framework of this last machine.

Mr. Wright—In our frame the main body is made of spruce—the very best straight-grained spruce—which is almost as strong as the hard woods. The uprights and nearly all of the spars are made of spruce. The covering is of cloth.

Mr. Churchill—Have you made any experiments in propelling a machine with a motor?

Mr. Wright—We have not applied a motor to any of our machines. The driving force has been gravity.

Mr. Seddon—Have you followed the late experiments of Prof. Bell, and what do you think of them?

Mr. Wright—It is very bad policy to ask one flying-machine man about the experiments of another, because every flying-machine man thinks that his method is the only correct one. Prof. Bell is working on the plan of getting a machine of very great structural strength and one which he thinks can be maintained easily. I think his principal idea is simply the method of construction to get something strong.

Mr. W. J. Wilson—I would like to ask Mr. Wright how he arrives at the area of the bird's wings.

Mr. Wright—The statement in regard to the area of the buzzard's wing was made on the authority of others. I have never measured one myself. As I understand it, the method is this: The bird, after being killed, is laid out flat, as nearly as possible in its position when flying and a line is drawn around the contour, and then the area is computed.

Mr. Warder—Does the bird throw the wing up or down without changing the axis of the body, or is it necessary to change the axis of the body at the same time he changes the plane of the wings?

Mr. Wright—Most birds incline the body to change the plane of the wings. Some years ago Prof. Marey made photographs of the flight of birds, employing a camera making fifty exposures a second. From these pictures it would appear that the bird's body rocks. The wings are moved diagonally forward on the down stroke, and backward on the up stroke. At the end of the down stroke the wings are in front of the center of gravity so that the bird's body turns up in front and remains so while the wings are being raised with a backward movement. But the wings being thus brought back of the center of gravity the axis of the body tilts downward again. By this backward and forward motion of the wings the bird rocks its whole body and thus inclines the plane of its wings upward and downward with every stroke.

Mr. Churchill—Do you not utilize that principle, to a certain extent, in the front rudder? Has it that same effect?

Mr. Wright—We use the same principle that the bird uses in turning upward. That is, we get more pressure in front of the center of gravity. It may be that you misunderstood my statement in regard to my brother's experiments in low-gliding. I did not mean that he touched the ground; he kept 5 or 6 inches off the ground. Of course now and then he made a mistake and touched the ground.

Mr. Warder—In these glides that your brother made so close to the ground, do you not suppose there might have been a little more pressure than at 10 or 20 feet above the ground?

Mr. Wright—I do not think there is very much difference. We have found, by experimenting, that if you hold a surface stationary—almost touching the ground, it will have less lift than when it is up in the air. In gliding I do not think there will be very much difference.

A Visitor—I would like to ask first, whether you consider that the future flying machine will be the machine of the type you have been using, driven by screws, or whether it will be a machine having a flapping motion.

Another thought that occurred to me was that perhaps the machine would be less liable to capsize if the wings were on a dihedral angle of about 45 degrees on a horizontal line.

Mr. Wright—The dihedral angle is the system used by Mr. Maxim and by Prof. Langley. The Maxim machine was overturned by a side gust of only moderate force. The Langley machine was tested only in dead calms when there were no side gusts to contend with. In our first machine we set the wings at a dihedral angle, but when we found that every little side wind threatened to capsize it, we drew the tips down like the wings of a gull. The gulls fly in the stormiest weather, while buzzards which use the dihedral angle avoid high winds. We found the gull position much the best. The dihedral angle is the proper solution of the problem for flight in still air, but it makes matters worse instead of better when the wind blows. Unfortunately the wind usually blows, so we have found it best to abandon this method and employ other means of securing lateral equilibrium.

As none of our experiments have been with power machines, my judgment of the relative merits of screws and wings may be of little value. I suspect that in efficiency they are not far from equal, but that screws possess mechanical advantages.

Mr. F. E. Hermanns—I would like to ask whether you regard 160 pounds per horse-power as the maximum amount that can be obtained?

Mr. Wright—I think not. Theoretically the horse-power required to sustain a given weight could be reduced to almost nothing by greatly increasing the wing area and thus reducing the speed through the air. But this ignores some practical considerations. To reduce the speed one-half, it would be necessary to increase the wing area four times in order to sustain the original weight, and much more than four times in order to sustain the increased weight resulting from the additions to the machine. It is evident, therefore, that while there is a way by which the weight carried per horse-power can be increased, the road is difficult and becomes steeper at every step. The same result could be obtained by reducing the angle of descent, but here also a limit is being approached. Until the limit is reached in both respects it is possible to increase the weight carried per horse-power. I think 200 pounds is attainable, possibly a little more.

DEFENDANTS' EXHIBIT, "WRIGHT BROTHERS ARTICLE IN CENTURY MAGAZINE for September, 1908".

Defendants' Exhibit
WRIGHT BROTHERS ARTICLE IN
CENTURY MAGAZINE FOR SEPT-
EMBER, 1908.
Beatrice Murns
Notary Public,
N.Y.Co. #3049.

Sept. 8/11.

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THE CENTURY MAGAZINE

VOL. LXXVI SEPTEMBER, 1908 No. 5

THE WRIGHT BROTHERS' AËROPLANE

BY ORVILLE AND WILBUR WRIGHT

WITH PICTURES FROM PHOTOGRAPHS SUPPLIED BY THE AUTHORS

THE article which follows is the first popular account of their experiments prepared by the inventors. Their accounts heretofore have been brief statements of bare accomplishments, without explanation of the manner in which results were attained. The article will be found of special interest, in view of the fact that they have contracted to deliver to the United States Government a complete machine, the trials of which are expected to take place about the time of the appearance of this number of THE CENTURY.—THE EDITOR.

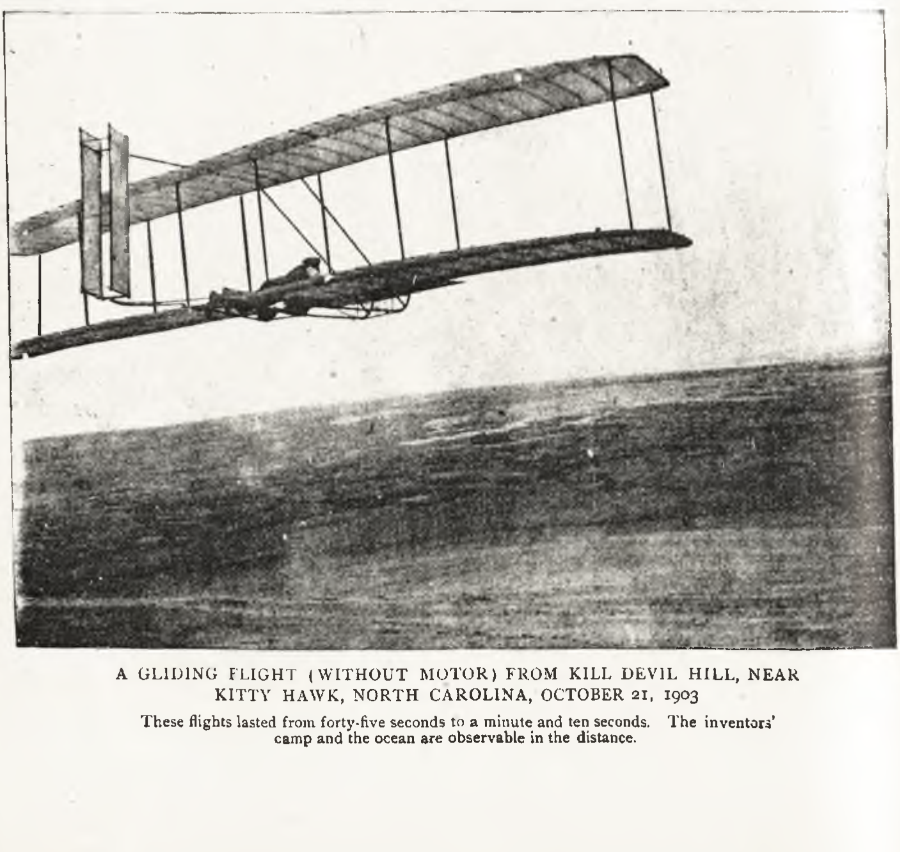
THOUGH the subject of aërial navigation is generally considered new, it has occupied the minds of men more or less from the earliest ages. Our personal interest in it dates from our childhood days. Late in the autumn of 1878, our father came into the house one evening with some object partly concealed in his hands, and before we could see what it was, he tossed it into the air. Instead of falling to the floor, as we expected, it flew across the room till it struck the ceiling, where it fluttered awhile, and finally sank to the floor. It was a little toy, known to scientists as a "hélicoptère," but which we, with sublime disregard for science, at once dubbed a "bat." It was a light frame of cork and bamboo, covered with paper, which formed two screws, driven in opposite directions by rubber bands under torsion. A toy so delicate lasted only a short time in the hands of small boys, but its memory was abiding.

Several years later we began building these hélicoptères for ourselves, making each one larger than that preceding. But, to our astonishment, we found that the larger the "bat," the less it flew. We did not know that a machine having only twice the linear dimensions of another would require eight times the power. We finally became discouraged, and returned to kite-flying, a sport to which we had devoted so much attention that we were regarded as experts. But as we became older, we had to give up this fascinating sport as unbecoming to boys of our ages.

It was not till the news of the sad death of Lilienthal reached America in the summer of 1896 that we again gave more than passing attention to the subject of flying. We then studied with great interest Chanute's "Progress in Flying Machines," Langley's "Experiments in Aerodynamics," the "Aëronautical Annuals" of 1905, 1906, and 1907, and several pamphlets published by the Smithsonian Institution, especially articles by Lilienthal and extracts from Mouillard's "Empire of the Air." The larger works gave us a good understanding of the nature of the flying problem, and the difficulties in past attempts to solve it, while Mouillard and Lilienthal, the great missionaries of the flying cause, infected us with their own unquenchable enthusiasm, and transformed idle curiosity into the active zeal of workers.

In the field of aviation there were two schools. The first, represented by such men as Professor Langley and Sir Hiram Maxim, gave chief attention to power flight; the second, represented by Lilienthal, Mouillard, and Chanute, to soaring flight. Our sympathies were with the latter school, partly from impatience at the wasteful extravagance of mounting delicate and costly machinery on wings which no one knew how to manage, and partly, no doubt, from the extraordinary charm and enthusiasm with which the apostles of soaring flight set forth the beauties of sailing through the air on fixed wings, deriving the motive power from the wind itself.

The balancing of a flyer may seem, at first thought, to be a very simple matter, yet almost every experimenter had found in this the one point which he could not satisfactorily master. Many different methods were tried. Some experimenters placed the center of gravity far below the wings, in the belief that the weight would naturally seek to remain at the lowest point. It was true, that, like the pendulum, it tended to seek the lowest point; but also, like the pendulum, it tended to oscillate in a manner destructive of all stability. A more satisfactory system, especially for lateral balance, was that of arranging the wings in the shape of a



A GLIDING FLIGHT (WITHOUT MOTOR) FROM KILL DEVIL HILL, NEAR KITTY HAWK, NORTH CAROLINA, OCTOBER 21, 1903

These flights lasted from forty-five seconds to a minute and ten seconds. The inventors' camp and the ocean are observable in the distance.

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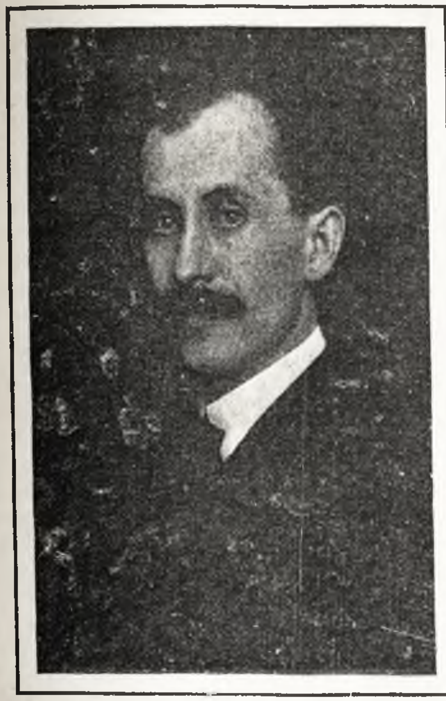


ORVILLE WRIGHT

From photographs by Hollinger

WILBUR WRIGHT

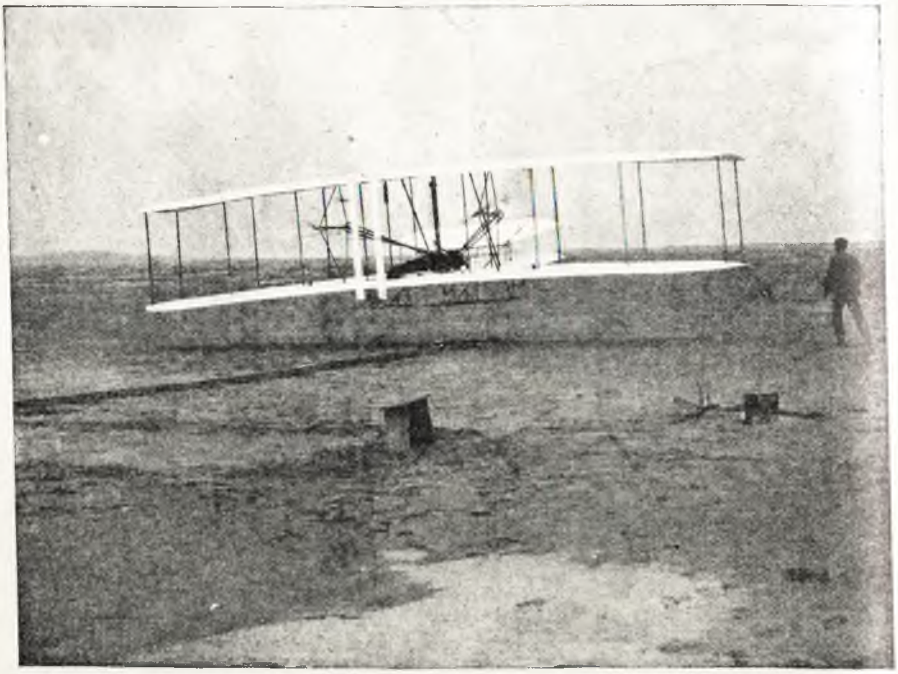
broad V, to form a dihedral angle, with the center low and the wing-tips elevated. In theory this was an automatic system, but in practice it had two serious defects: first, it tended to keep the machine oscillating; and, second, its usefulness was restricted to calm air.

In a slightly modified form the same system was applied to the fore-and-aft balance. The main aëroplane was set at a positive angle, and a horizontal tail at a negative angle, while the center of gravity was placed far forward. As in the case of lateral control, there was a tendency to constant undulation, and the very forces which caused a restoration of balance in calms, caused a disturbance of the balance in winds. Notwithstanding the known limitations of this principle, it had been embodied in almost every prominent flying-machine which had been built.

After considering the practical effect of the dihedral principle, we reached the conclusion that a flyer founded upon it might be of interest from a scientific point of view, but could be of no value in a practical way. We therefore resolved to try a fundamentally different principle. We would arrange the machine so that it would not tend to right itself. We would make it as inert as possible to the effects of change of direction or speed, and thus reduce the effects of wind-gusts to a minimum. We would do this in the fore-and-aft stability by giving the aëroplanes a peculiar shape; and in the lateral balance, by arching the surfaces from tip to tip, just the reverse of what our predecessors had done. Then by some suitable contrivance, actuated by the operator, forces should be brought into play to regulate the balance.

Lilienthal and Chanute had guided and balanced their machines by shifting the weight of the operator's body. But this method seemed to us incapable of expansion to meet large conditions, because the weight to be moved and the distance of possible motion were limited, while the disturbing forces steadily increased, both with wing area and with wind velocity. In order to meet the needs of large machines, we wished to employ some system whereby the operator could vary at will the inclination of different parts of the wings, and thus obtain from the wind forces to restore the balance which the wind itself had disturbed. This could easily be done by using wings capable of being warped, and by supplementary adjustable surfaces in the shape of rudders. As the forces obtainable for control would necessarily increase in the same ratio as the disturbing forces, the method seemed capable of expansion to an almost unlimited extent. A happy device was discovered whereby the apparently rigid system of superposed surfaces, invented by Wenham, and improved by Stringfellow and Chanute, could be warped in a most unexpected way, so that the aëroplanes could be presented on the right and left sides at different angles to the wind. This, with an adjustable, horizontal front rudder, formed the main feature of our first glider.

The period from 1885 to 1900 was one of unexampled activity in aëronautics, and for a time there was high hope that the age of flying was at hand. But Maxim, after spending $100,000, abandoned the work; the Ader machine, built at the expense of the French Government, was a failure; Lilienthal and Pilcher were killed in experiments; and Chanute and many others, from one cause or another, had relaxed their efforts, though it subsequently became known that Professor Langley was still secretly at work on a machine for the United States Government. The public, discouraged by the failures and tragedies just witnessed, considered flight beyond the reach of man, and classed its adherents with the inventors of perpetual motion.



FIRST FLIGHT OF THE WRIGHT BROTHERS' FIRST MOTOR MACHINE, AT KILL DEVIL HILL, DECEMBER 17, 1903

This picture shows the machine just after lifting from the track, flying against a wind of twenty-four miles an hour

We began our active experiments at the close of this period, in October, 1900, at Kitty Hawk, North Carolina. Our machine was designed to be flown as a kite, with a man on board, in winds of from fifteen to twenty miles an hour. But, upon trial, it was found that much stronger winds were required to lift it. Suitable winds not being plentiful, we found it necessary, in order to test the new balancing system, to fly the machine as a kite without a man on board, operating the levers through cords from the ground. This did not give the practice anticipated, but it inspired confidence in the new system of balance.

In the summer of 1901 we became personally acquainted with Mr. Chanute. When he learned that we were interested in flying as a sport, and not with any expectation of recovering the money we were expending on it, he gave us much encouragement. At our invitation, he spent several weeks with us at our camp at Kill Devil Hill, four miles south of Kitty Hawk, during our experiments of that and the two succeeding years. He also witnessed one flight of the power machine near Dayton, Ohio, in October, 1904.

FLIGHT AT SIMMS STATION, NEAR DAYTON, OHIO, NOVEMBER 9, 1904

The machine described almost four complete circles, covering a distance of three miles in five minutes and four seconds.

The machine of 1901 was built with the shape of surface used by Lilienthal, curved from front to rear like the segment of a parabola, with a curvature $\frac{1}{12}$ the depth of its cord; but to make doubly sure that it would have sufficient lifting capacity when flown as a kite in fifteen- or twenty-mile winds, we increased the area from 165 square feet, used in 1900, to 308 square feet—a size much larger than Lilienthal, Pilcher, or Chanute had deemed safe. Upon trial, however, the lifting capacity again fell very far short of calculation, so that the idea of securing practice while flying as a kite, had to be abandoned. Mr. Chanute, who witnessed the experiments, told us that the trouble was not due to poor construction of the machine. We saw only one other explanation—that the tables of air-pressures in general use were incorrect.

We then turned to gliding—coasting down hill on the air—as the only method of getting the desired practice in balancing a machine. After a few minutes' practice we were able to make glides of over 300 feet, and in a few days were safely operating in twenty-seven-mile[1] winds. In these experiments we met with several unexpected phenomena. We found that, contrary to the teachings of the books, the center of pressure on a curved surface traveled backward when the surface was inclined, at small angles, more and more edgewise to the wind. We also discovered that in free flight, when the wing on one side of the machine was presented to the wind at a greater angle than the one on the other side, the wing with

[1] The gliding flights were all made against the wind. The difficulty in high winds is in maintaining balance, not in traveling against the wind.

THREE-QUARTER VIEW OF A FLIGHT AT SIMMS STATION, NOVEMBER 16, 1904

The location of the Springfield turnpike and the Springfield electric road is indicated by the trees.

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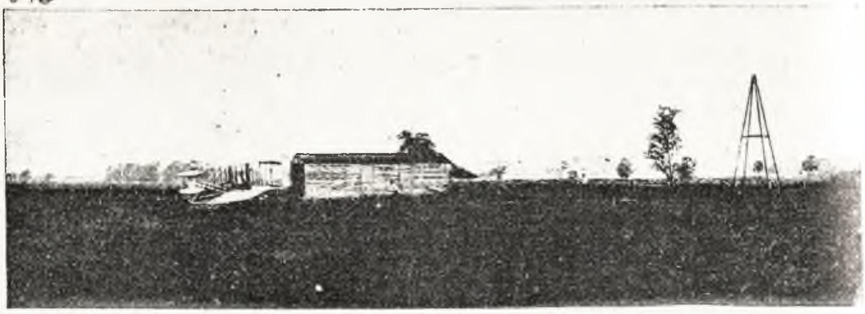


THE START OF THE FIRST FLIGHT OF 1905

The machine is seen just leaving the track, the initial velocity being obtained by its own motive power, assisted by a cable with falling weight, rigged to the derrick, especially for use in calm weather.

the greater angle descended, and the machine turned in a direction just the reverse of what we were led to expect when flying the machine as a kite. The larger angle gave more resistance to forward motion, and reduced the speed of the wing on that side. The decrease in speed more than counterbalanced the effect of the larger angle. The addition of a fixed vertical vane in the rear increased the trouble, and made the machine absolutely dangerous. It was some time before a remedy was discovered. This consisted of movable rudders working in conjunction with the twisting of the wings. The details of this arrangement are given in our patent specifications, published several years ago.

The experiments of 1901 were far from encouraging. Although Mr. Chanute assured us that, both in control and in weight carried per horse-power, the results obtained were better than those of any of our predecessors, yet we saw that the calculations upon which all flying-machines had been based were unreliable, and that all were simply groping in the dark. Having set out with absolute faith in the existing scientific data, we were driven to doubt one thing after another, till finally, after two years of experiment, we cast it all aside, and decided to rely entirely upon our own investigations. Truth and error were everywhere so intimately mixed as to be undistinguishable. Nevertheless, the time expended in preliminary study of books was not misspent, for they gave us a good general understanding of the subject, and enabled us at the outset to avoid effort in many directions in which results would have been hopeless.

The standard for measurements of wind-pressures is the force produced by a current of air of one mile per hour velocity striking square against a plane of one square-foot area. The practical difficulties of obtaining an exact measurement of this force have been great. The measurements by different recognized authorities vary fifty per cent. When this simplest of measurements presents so great difficulties, what shall be said of the troubles encountered by those who attempt to find the pressure at each angle as the plane is inclined more and more edgewise to the wind? In the eighteenth century the French Academy prepared tables giving such information, and at a later date the Aëronautical Society of Great Britain made similar experiments. Many persons likewise published measurements and formulas; but the results were so discordant that Professor Langley undertook a new series of measurements, the results of which form the basis of his celebrated work, "Experiments in Aërodynamics." Yet a critical examination of the data upon which he based his conclusions as to the pressures at small angles shows results so various as to make many of his conclusions little better than guess-work.

To work intelligently, one needs to know the effects of a multitude of variations that could be incorporated in the surfaces of flying-machines. The pressures on squares are different from those on rectangles, circles, triangles, or ellipses; arched surfaces differ from planes, and vary among themselves according to the depth of curvature; true arcs differ from parabolas, and the latter differ among themselves; thick surfaces differ from thin, and surfaces thicker in one place than another vary in pressure when the positions of maximum thickness are different; some surfaces are most efficient at one angle, others at other angles. The shape of the edge also makes a difference, so that thousands of combinations are possible in so simple a thing as a wing.

We had taken up aëronautics merely as a sport. We reluctantly entered upon the scientific side of it. But we soon found the work so fascinating that we were drawn into it deeper and deeper. Two testing-machines were built, which we believed would avoid the errors to which the measurements of others had been subject. After making preliminary measurements on a great number of different-shaped surfaces, to secure a general understanding of the subject, we began systematic measurements of standard surfaces, so varied in design as to bring out the underlying causes of differences noted in their pressures. Measurements were tabulated on nearly fifty of these at all angles from zero to 45 degrees, at intervals of 2½ degrees. Measurements were also secured showing the effects on each other when surfaces are superposed, or when they follow one another.

Some strange results were obtained. One surface, with a heavy roll at the front edge, showed the same lift for all angles from 7½ to 45 degrees. A square plane, contrary to the measurements of all our predecessors, gave a greater pressure at 30 degrees than at 45 degrees. This seemed so anomalous that we were almost ready to doubt our own measurements, when a simple test was suggested. A weather-vane, with two planes attached to the pointer at an angle of 80 degrees with each other, was made. According to our tables, such a vane would be in unstable equilibrium when pointing directly into the wind; for if by chance the wind should happen to strike one plane at 39 degrees and the other at 41 degrees, the plane with the smaller angle would have the greater pressure, and the pointer would be turned still farther out of the course of the wind until the two vanes again secured equal pressures, which would be at approximately 30 and 50 degrees. But the vane performed in this very manner. Further corroboration of the tables was obtained in experiments with a new glider at Kill Devil Hill the next season.

SIDE VIEW, SHOWING THE MACHINE TRAVELING TO THE RIGHT, WITH DOUBLE HORIZONTAL RUDDER IN FRONT, AND DOUBLE VERTICAL RUDDER BEHIND

This flight was made September 29, 1905, and the distance covered was twelve miles.

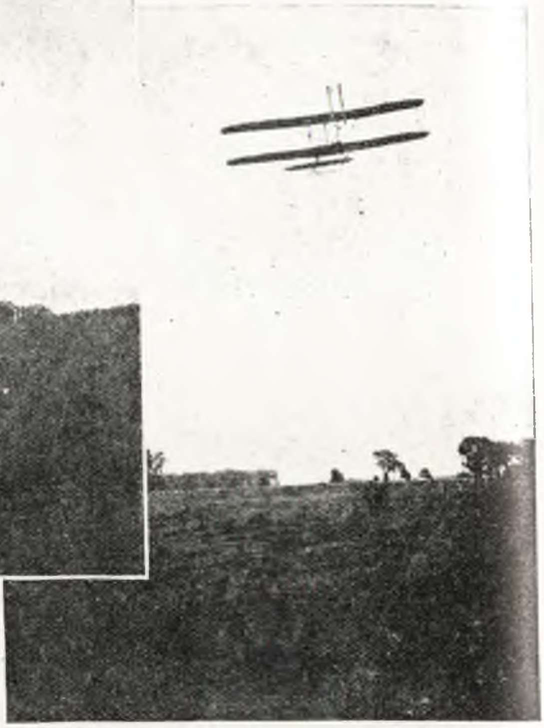
In September and October, 1902, nearly one thousand gliding flights were made, several of which covered distances of over 600 feet. Some, made against a wind of thirty-six miles an hour, gave proof of the effectiveness of the devices for control. With this machine, in the autumn of 1903, we made a number of flights in which we remained in the air for over a minute, often soaring for a considerable time in one spot, without any descent at all. Little wonder that our unscientific assistant should think the only thing needed to keep it indefinitely in the air would be a coat of feathers to make it light!

With accurate data for making calculations, and a system of balance effective in winds as well as in calms, we were now in a position, we thought, to build a successful power-flyer. The first designs provided for a total weight of 600 pounds, including the operator and an eight horse-power motor. But, upon completion, the motor gave more power than had been estimated, and this allowed 150 pounds to be added for strengthening the wings and other parts.

Our tables made the designing of the wings an easy matter; and as screw-propellers are simply wings traveling in a spiral course, we anticipated no trouble from this source. We had thought of getting the theory of the screw-propeller from the marine engineers, and then, by applying our tables of air-pressures to their formulas of designing air-propellers suitable for our purpose. But so far as we could learn, the marine engineers possessed only empirical formulas, and the exact action of the screw-propeller, after a century of use, was still very obscure. As we were not in a position to undertake a long series of practical experiments to discover a propeller suitable for our machine, it seemed necessary to obtain such a thorough understanding of the theory of its reactions as would enable us to design them from calculation alone. What at first seemed a simple problem became more complex the longer we studied it. With the machine moving forward, the air flying backward, the propellers turning sidewise, and nothing standing still, it seemed impossible to find a starting-point from which to trace the various simultaneous reactions. Contemplation of it was confusing. After long arguments, we often found ourselves in the ludicrous position of each having been converted to the other's side, with no more agreement than when the discussion began.

It was not till several months had passed, and every phase of the problem had been thrashed over and over, that the various reactions began to untangle themselves. When once a clear understanding had been obtained, there was no difficulty in designing suitable propellers, with proper diameter, pitch, and area of blade, to meet the requirements of the flyer.

FRONT VIEW OF THE FLIGHT OF OCTOBER 4, 1905



REAR VIEW OF THE FLIGHT OF OCTOBER 4, 1905

In this flight twenty miles were accomplished in thirty-three minutes and seventeen seconds. The machine used in the extensive experiments at Kitty Hawk, North Carolina, last spring, was virtually of similar construction, adapted to two passengers.

High efficiency in a screw-propeller is not dependent upon any particular or peculiar shape, and there is no such thing as a "best" screw. A propeller giving a high dynamic efficiency when used upon one machine, may be almost worthless when used upon another. The propeller should in every case be designed to meet the particular conditions of the machine to which it is to be applied. Our first propellers, built entirely from calculation, gave in useful work 66 per cent. of the power expended. This was about one third more than had been secured by Maxim or Langley.

The first flights with the power-machine were made on the 17th of December, 1903. Only five persons besides ourselves were present. These were Messrs. John T. Daniels, W. S. Dough, and A. D. Etheridge of the Kill Devil Life Saving Station; Mr. W. C. Brinkley of Manteo, and Mr. John Ward of Naghead. Although a general invitation had been extended to the people living within five or six miles, not many were willing to face the rigors of a cold December wind in order to see, as they no doubt thought, another flying-machine *not* fly. The first flight lasted only twelve seconds, a flight very modest compared with that of birds, but it was, nevertheless, the first in the history of the world in which a machine carrying a man had raised itself by its own power into the air in free flight, had sailed forward on a level course without reduction of speed, and had finally landed without being wrecked. The second and third flights were a little longer, and the fourth lasted fifty-nine seconds, covering a distance of 852 feet over the ground against a twenty-mile wind.

After the last flight, the machine was carried back to camp and set down in what was thought to be a safe place. But a few minutes later, while we were engaged in conversation about the flights, a sudden gust of wind struck the machine, and started to turn it over. All made a rush to stop it, but we were too late. Mr. Daniels, a giant in stature and strength, was lifted off his feet, and falling inside, between the surfaces, was shaken about like a rattle in a box as the machine rolled over and over. He finally fell out upon the sand with nothing worse than painful bruises, but the damage to the machine caused a discontinuance of experiments.

In the spring of 1904, through the kindness of Mr. Torrence Huffman of Dayton, Ohio, we were permitted to erect a shed, and to continue experiments, on what is known as the Huffman Prairie, at Simms Station, eight miles east of Dayton. The new machine was heavier and stronger, but similar to the one flown at Kill Devil Hill. When it was ready for its first trial, every newspaper in Dayton was notified, and about a dozen representatives of the press were present. Our only request was that no pictures be taken, and that the reports be unsensational, so as not to attract crowds to our experiment-grounds. There were probably fifty persons altogether on the ground. When preparations had been completed, a wind of only three or four miles was blowing, —insufficient for starting on so short a track,—but since many had come a long way to see the machine in action, an attempt was made. To add to the other difficulty, the engine refused to work properly. The machine, after running the length of the track, slid off the end without rising into the air at all. Several of the newspaper men returned the next day, but were again disappointed. The engine performed badly, and after a glide of only sixty feet, the machine came to the ground. Further trial was postponed till the motor could be put in better running condition. The reporters had now, no doubt, lost confidence in the machine, though their reports, in kindness, concealed it. Later, when they heard that we were making flights of several minutes' duration, knowing that longer flights had been made with air-ships, and not knowing any essential difference between air-ships and flying-machines, they were but little interested.

We had not been flying long in 1904 before we found that the problem of equilibrium had not as yet been entirely solved. Sometimes, in making a circle, the machine would turn over sidewise despite anything the operator could do, although, under the same conditions in ordinary straight flight, it could have been righted in an instant. In one flight, in 1905, while circling around a honey locust-tree at a height of about fifty feet, the machine suddenly began to turn up on one wing, and took a course toward the tree. The operator, not relishing the idea of landing in a thorn-tree, attempted to reach the ground. The left wing, however, struck the tree at a height of ten or twelve feet from the ground, and carried away several branches; but the flight, which had already covered a distance of six miles, was continued to the starting-point.

The causes of these troubles—too technical for explanation here—were not entirely overcome till the end of September, 1905. The flights then rapidly increased in length, till experiments were discontinued after the 5th of October, on account of the number of people attracted to the field. Although made on a ground open on every side, and bordered on two sides by much traveled thoroughfares, with electric cars passing every hour, and seen by all the people living in the neighborhood for miles around, and by several hundred others, yet these flights have been made by some newspapers the subject of a great "mystery."

A practical flyer having been finally realized, we spent the years 1906 and 1907 in constructing new machines and in business negotiations. It was not till May of this year that experiments (discontinued in October, 1905) were resumed at Kill Devil Hill, North Carolina. The recent flights were made to test the ability of our machine to meet the requirements of a contract with the United States Government to furnish a flyer capable of carrying two men and sufficient fuel supplies for a flight of 125 miles, with a speed of forty miles an hour. The machine used in these tests was the same one with which the flights were made at Simms Station in 1905, though several changes had been made to meet present requirements. The operator assumed a sitting position, instead of lying prone, as in 1905, and a seat was added for a passenger. A larger motor was installed, and radiators and gasolene reservoirs of larger capacity replaced those previously used. No attempt was made to make high or long flights.

In order to show the general reader the way in which the machine operates, let us fancy ourselves ready for the start. The machine is placed upon a single rail track facing the wind, and is securely fastened with a cable. The engine is put in motion, and the propellers in the rear whir. You take your seat at the center of the machine beside the operator. He slips the cable, and you shoot forward. An assistant who has been holding the machine in balance on the rail, starts forward with you, but before you have gone fifty feet the speed is too great for him, and he lets go. Before reaching the end of the track the operator moves the front rudder, and the machine lifts from the rail like a kite supported by the pressure of the air underneath it. The ground under you is at first a perfect blur, but as you rise the objects become clearer. At a height of one hundred feet you feel hardly any motion at all, except for the wind which strikes your face. If you did not take the precaution to fasten your hat before starting, you have probably lost it by this time. The operator moves a lever: the right wing rises, and the machine swings about to the left. You make a very short turn, yet you do not feel the sensation of being thrown from your seat so often experienced in automobile and railway travel. You find yourself facing toward the point from which you started. The objects on the ground now seem to be moving at much higher speed, though you perceive no change in the pressure of the wind on your face. You know then that you are traveling with the wind. When you near the starting-point, the operator stops the motor while still high in the air. The machine coasts down at on oblique angle to the ground, and after sliding fifty or a hundred feet comes to rest. Although the machine often lands when traveling at a speed of a mile a minute, you feel no shock whatever, and cannot, in fact, tell the exact moment at which it first touched the ground. The motor close beside you kept up an almost deafening roar during the whole flight, yet in your excitement, you did not notice it till it stopped!

Our experiments have been conducted entirely at our own expense. In the beginning we had no thought of recovering what we were expending, which was not great, and was limited to what we could afford for recreation. Later, when a successful flight had been made with a motor, we gave up the business in which we were engaged, to devote our entire time and capital to the development of a machine for practical uses. As soon as our condition is such that constant attention to business is not required, we expect to prepare for publication the results of our laboratory experiments, which alone made an early solution of the flying problem possible.

DEFENDANTS' EXHIBIT "TURNER ARTICLE".

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THE MEN WHO LEARNED TO FLY

THE WRIGHT BROTHERS' STORY OF THEIR EXPERIMENTS, THE SENSATIONS OF FLIGHT, AND THEIR ESTIMATE OF THE FUTURE OF THE AEROPLANE

BY

GEORGE KIBBE TURNER

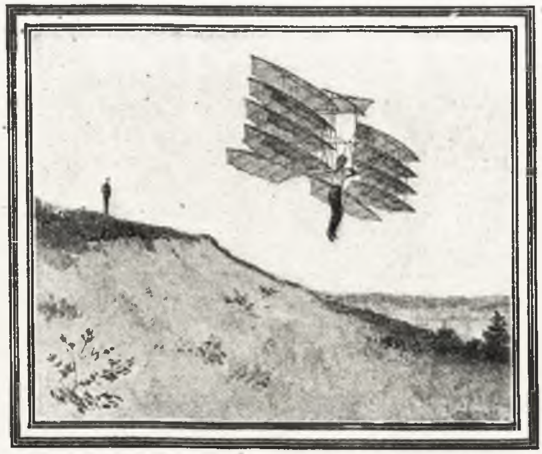
AUTHOR OF "GALVESTON: A BUSINESS CORPORATION"

ILLUSTRATIONS FROM PHOTOGRAPHS

IN 1888 scientific authorities could demonstrate mathematically that a mechanical flying-machine was impossible. Formulae — absolutely fundamental formulae proving this — had remained almost undisturbed since they were proposed by Sir Isaac Newton. Any flying-machine must be too heavy to be supported by the air. Yet, it was also well understood that many birds were a thousand times heavier than the air they flew in.

During the eighties a German mechanical engineer, Otto Lilienthal, studied the mechanics of the flight of birds, and decided we knew very little about the laws of flying. The only way for a man to learn to fly, he believed, was to start flying. In 1891 he began to fly. Using wings built like those of soaring birds, such as the hawk and buzzard, he precipitated himself from steep hills, against strong winds, and glided down through the air into the valleys. In more than two thousand flights — varying from a few yards to a fifth of a mile in length — he established entirely new views concerning the support of moving bodies by the air. In August, 1896, Lilienthal's wings gave way in a sudden gust of wind. He fell fifty feet, broke his back, and died the following day.

Percy S. Pilcher of England continued similar experiments in soaring flight. In September, 1899, his wings also broke; he dropped thirty feet through the air, and died of his injuries two days later. With the death of the two leading European experimenters, the principal burden of the discovery of mechanical flight was taken up by Americans.



CHANUTE'S MULTIPLE-WING MACHINE (1896)

In 1887-89, Professor S. P. Langley, subsequently of the Smithsonian Institution, by means of experiments with impelled metal plates, established new scientific formulae concerning the support given flying-planes by the air, and published them in 1891; in 1896 he made a small steam-aëroplane which flew three quarters of a mile down the Potomac River. In 1896 Octave Chanute of Chicago, assisted by A. M. Herring and others as active operators and designers, made and tested new and better types of glidingm-achines as the result of experiments on the shores of Lake Michigan.

THE FIRST OF THE GLIDING-MACHINES

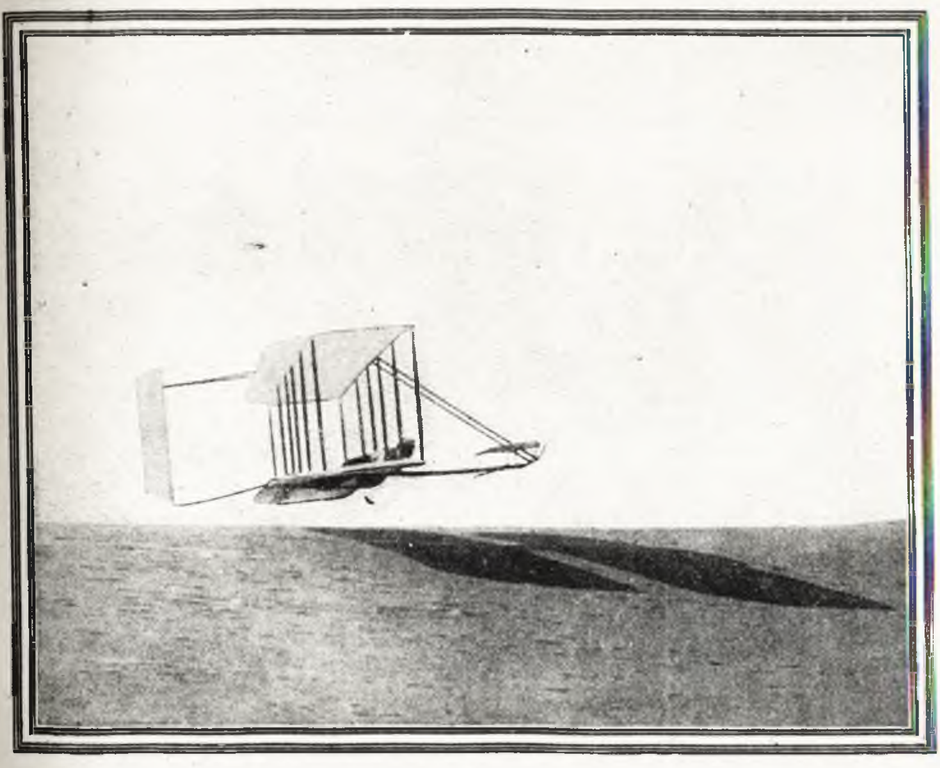
LILIENTHAL OPERATING HIS BIRDLIKE AËROPLANE

In 1900 the Wright brothers, two young bicycle-makers of Dayton, Ohio, started experiments in air-gliding in a machine operated on a new principle. In 1903 they added a gasoline-engine to their aëroplane, and began to navigate the air in mechanical flying-machines. It is a well-established fact that they have been flying on mechanically driven aëroplanes for the past four years. Exactly how they do this is not known; they are keeping their method secret, in the belief that this is the only way in which they can secure a financial return from their invention.

The Wright Brothers and their Story

Before the Wright brothers sailed abroad last summer, for the demonstrations of their machines before foreign war departments, they discussed with me for an entire morning their invention, the theories and sensations of flight, and their personal beliefs and ambitions in connection with their discovery — two lean, quiet men in a dingy, commonplace little brick bicycle-shop; pleasant, unassuming, most approachable, but shy and silent under the oppression of the greatest secret of the time. Orville, of the more social and conversational temperament, did the greater share of the talking — an amiable, kindly-faced man of thirty-five. Wilbur — prematurely bald, about forty, with the watchful eyes, marked facial lines, and dry, brief speech of a naturally reticent man — corroborated or amplified his brother's statements. It would be both unnecessary and impossible to divide the story of their invention between the two men exactly as they told it. Practically their story, like their invention, was the product of one mind — one dual mind. I will tell it as a simple statement of fact, without attempting to reproduce the exact conversation. It is the extraordinary information, and not the method of statement, which is of importance. The story follows:

In 1896 we saw a little press despatch in a newspaper telling of the death of Lilienthal by a fall from his machine. This, and the reading of the "Aëronautical Annual" for 1897, started our first active interest in the problem of aërial navigation. We have been at work at it ever since — first as a mere scientific pastime, but for nearly ten years as the most serious purpose of our



THE WRIGHT BROTHERS' LATEST GLIDER

THE HORIZONTAL POSITION OF THE OPERATOR, THE BALANCING RUDDER IN FRONT, AND THE SLIGHT CURVES OF THE DOUBLE WING SURFACES SHOWN IN THIS PHOTOGRAPH, REPRESENT THREE OF THE WRIGHT BROTHERS' CHIEF CONTRIBUTIONS TO THE ART OF FLYING

life. Up to 1900 we had merely studied and made laboratory experiments; in that year we started actual experiments in flying on our gliding-machine.

At that time (1900) there was really only one problem remaining to be solved to make a workable flying-machine — the problem of equilibrium. Men already knew how to make aëroplanes that would support them when driven through the air at a sufficient speed, and there were engines light enough per horse-power to propel the aëroplane at the necessary speed, and to carry their own weight and the weight of an operator. There were plenty of aëroplanes that would fly in still air. What was needed was an air-ship that would not capsize when the wind was blowing.

The Turbulence of the Air

No one who has not navigated the air can appreciate the real difficulty of mechanical flight. To the ordinary person it seems a miracle that a thin solid plane can be driven up into the air by machinery; but for over ten years that miracle has been accomplished. On the other hand, the great problem — the problem of equilibrium — never occurs to any one who has not actually tried flying. The real question of the flying-machine is how to keep it from turning over.

The chief trouble is the turmoil of the air. The common impression is that the atmosphere runs in comparatively regular currents which we call winds. No one who has not been thrown about on a gliding-aëroplane — rising or falling ten, twenty, or even thirty feet in a few seconds — can understand how utterly wrong this idea is. The air along the surface of the earth, as a matter of fact, is continually churning. It is thrown upward from every irregularity, like sea breakers on a coast-line; every hill and tree and building sends up a wave or slanting current. And it moves, not directly back and forth upon its coast-line, like the sea, but in whirling rotary masses. Some of these rise up hundreds of yards. In a fairly strong wind the air near the earth is more disturbed than the whirlpools of Niagara.

Equilibrium—the Real Problem of Flying

The problem of mechanical flight is how to balance in this moving fluid which supports the flying-machine; or, technically speaking, how to make the center of gravity coincide with the center of air-pressure. Now, the irregular action of the air is naturally reflected in the movement of this center of pressure. If a wind should blow against a plane at right angles to it, the center of pressure would be in the center of the plane. But an aëroplane must be sailed at a very slight angle to the direction in which it is moving. That means that the center of air-pressure is well forward on the surfaces of the machine. Every sudden breeze that blows strikes strongly on the front of the plane and very little on the back of it. The result is that the force of every gust of wind is multiplied by leverage in its tendency to tip the plane over. The wind often veers several times a second, quicker than thought, and the center of pressure changes with it. It is as difficult to follow this center of pressure as to keep your finger on the flickering blot of light from a prism swinging in the sun.

ORVILLE WRIGHT

Lilienthal balanced himself in his gliding-machine by shifting his weight; his body hung down below his wings, resting on his elbows. In Chanute's machines the operator did nearly the same, swinging below the wings, with his arm-pits supported on little parallel bars.* In both machines the rapid motion of the body was difficult and exhausting work, and the size of the machine was definitely limited by the weight which the operator could carry on his back. In our gliding-machine we introduced an entirely new method; we governed the motion of the center of pressure, not by shifting our weight, but by shifting the rudder and surfaces of the machine against the action of the air. Before this can be understood there must be some idea of the wings of our machine.

The Development of Artificial Wings

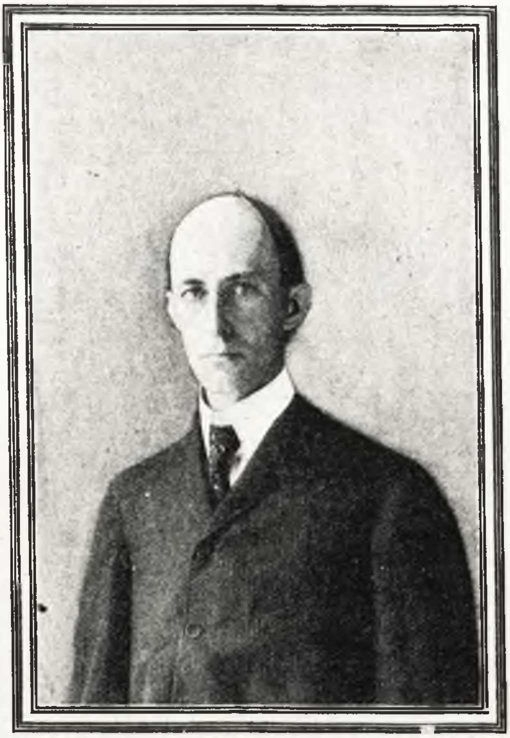
Lilienthal, in his first flights, copied the wings of soaring birds very closely; later he used wings in two planes, that is, one above another. Chanute experimented with wings of as many as five planes, but, like Lilienthal, secured the best results with the "double-deckers." When we took up our gliding experiments, we believed that these wings in two planes had been shown to be the best type for the aëroplane; they were stronger than any other, allowing the principle of the truss-bridge to be used in their bracing, and they were more compact and manageable than the single-surface wings.

By 1900 we had designed our type of gliding-machine. It was made of cloth and spruce and steel wire, very much after the style of the Chanute double-decker—a little larger than his. But in its principle of operation it was entirely different. The operator, instead of swinging below the wings, lay fore and aft across the middle of the lower wing upon his stomach. In front of him — extended out before the machine instead of behind it — was a horizontal rudder. This guided the gliding-machine up and down. But it did much more than that: it counterbalanced the movement of the center of pressure backward and forward on the main surfaces of the machine; that is, it kept the aëroplane from pitching over backward or forward. For steering and balancing sideways we turned the outside edges of the

* Chanute tested three types of his own, in two of which the wings were automatically readjusted by the wind-pressure. The multiple-wing machine was his first type.

wings against the air-pressure by cords controlled by movements of the operator's body. The tail used in previous gliding-machines was given up. Our idea was to secure a machine which, with a little practice, could be balanced and steered semi-automatically, by reflex action, just as a bicycle is. There is no time to be given to conscious thought in balancing an aëroplane; the action of the air is too rapid.

The shape of the wings offered another important problem. Langley and other experimenters had favored wings set at a dihedral angle — that is, each slanting upward from the center where they joined. They hoped to secure a stable equilibrium by this. We believed that this device would work well in still air, but that in the shifting, troubled air of out-of-doors it would add to the danger of turning over. These wings are made after the style of the wings of a soaring buzzard — a bird which avoids high winds. We curved ours down a little at the tips, after the fashion of the soaring gull — a rough-weather bird. Our wings did not approach the exact form of birds' wings so closely as Lilienthal's or Pilcher's. They were made of cloth fixed to two rectangular wooden frames, fastened one above the other by wooden braces and wires. The cloth surfaces were arched by ribs between these frames to secure the curved surfaces of birds' wings, which Lilienthal had shown were essential to the best results in flying.



WILBUR WRIGHT

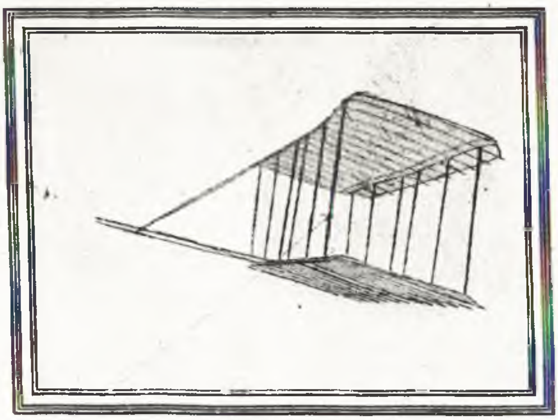
Those Animated Aëroplanes, the Birds

We had also worked out a new method of practice with gliding-machines which we hoped to use. Lilienthal and Chanute had obtained their experience in flying by the operator's launching himself from a hill and gliding down on to lower land. This involved carrying back their apparatus, after a short flight, to the top of the hill again. Because of the difficulties of this awkward method, although Lilienthal had made over two thousand flights, we calculated that in all his five years of experiment he could not have been actually practising flying more than five hours — far too short a time for the ordinary man to learn to ride a bicycle. It was our plan to follow the example of soaring birds, and find a place where we could be supported by strong rising winds.

A bird is really an aëroplane. The portions of its wings near the body are used as planes of support, while the more flexible parts outside, when flapped, act as propellers. Some of the soaring birds are not much more than animated sailing-machines. A buzzard can be safely kept in an open pen thirty feet across and ten feet high. He cannot fly out of it. In fact, we know from observation made by ourselves that he cannot fly for any distance up a grade of one to six. Yet these birds sailing through the air are among the commonest sights through a great section of the country. Every one who has been outdoors has seen a buzzard or a hawk soaring; every one who has been at sea has seen the gulls sailing after a steamship for hundreds of miles with scarcely a movement of the wings. All of these birds are doing the same thing — they are balancing on rising currents of air. The buzzards and hawks find the currents blowing upward off the land; the gulls that follow the steamers from New York to Florida are merely sliding downhill a thousand miles on rising currents in the wake of the steamer in the atmosphere, and on the hot air rising from her smokestacks.

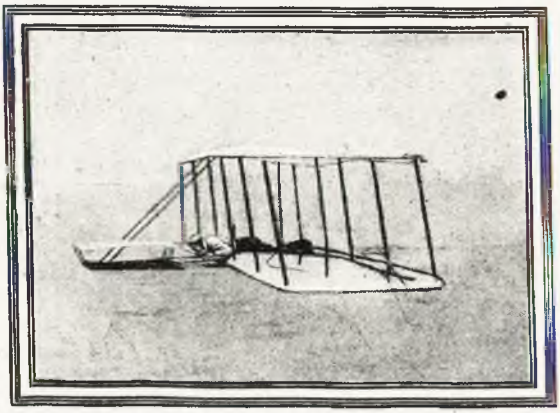
A Plan which Failed

On a clear, warm day the buzzards find the high, rotary, rising currents of air, and go sailing around and around in them. On damp, windy days they hang above the edge of a steep hill on the air which comes rising up its slope. From their position in the air they can glide down at will. Now, we planned to take our gliding-machine, in 1900, to some section where there were strong, constant winds, and try soaring and gliding in the manner of these birds. We calculated, by Lilienthal's tables, that our gliding-machine, which had 165 square feet of surface, should be sustained by a wind of twenty-one miles an hour. We planned to raise the machine — operator and all — like a kite in this wind, men holding ropes at the end of each wing. When the machine had started soaring at the end of the ropes, these would be released and the operator could glide to the earth. In this way we hoped we would avoid the weary dragging back of the machine necessary in the operation of gliding downhill, and could get hours instead of seconds of practice in flying.



THE FIRST WRIGHT GLIDER (1900)

Winds of between sixteen and twenty-five miles an hour are not unusual at points on the Atlantic coast, and after a little study and inquiry we located the place we wanted at Kitty Hawk, North Carolina, on the sand-dunes which separate Albemarle Sound from the Atlantic Ocean. There were strong winds there, and steep hills of soft sand for use in gliding from heights, if we found that necessary. In the summer of 1900 we took our first gliding-machine there for experiment.



THE SECOND WRIGHT GLIDER (1901)

We found on this trip that our plan to practise by raising the machine like a kite was impracticable. It required a wind of nearly thirty miles an hour to support our aëroplane at an angle flat or level enough to be of any use in gliding. The surfaces of this first machine were not curved deeply enough, in the first place, but we found also that the tables of the earlier experimenters concerning the lifting power of the wind were not accurate. So we had to give up our plan of soaring, and start gliding from hills, as the others had done. Instead of hours of gliding, as we had hoped, we had only two minutes of actual sailing in the air that year. Nevertheless we came to some very clear and satisfactory conclusions. We found that our new and revolutionary method of steering and balancing by shifting surfaces instead of by weights worked well, and that it promised to work in large as well as in small machines.

A Revolution in the Art of Flying

In 1901 we started gliding again at Kitty Hawk, on a machine nearly twice as large as had been counted safe before. This machine had a surface of 308 square feet, whereas Lilienthal's had had 151, Pilcher's 165, and Chanute's double-decker 134. Our new glider was 22 feet from tip to tip, and the main surfaces were 7 feet across and 6 feet apart. It weighed 100 pounds, 240 or 250 with its operator. This machine, like the first one, had no tail. Its trials were so successful that the next year

(1902) we made another on advanced lines. The main surfaces of this were 32 feet from tip to tip and only 5 feet across. In addition to the devices in the former gliders, we used a vertical tail on this, as an additional method of keeping the lateral balance. We made between seven hundred and one thousand glides with this — the longest of which was 622 feet. By the actual tests of flying, we established many points definitely, and made many changes in the tables of calculation for aërial flight.

Eighteen Miles an Hour — the Rate when Flight Begins

We found that a rate of eighteen miles an hour through the air would sustain our aëroplane and its operator in flight. A rate of sixteen miles would sustain it, but at too great an angle to allow progress through the air. A wind of eighteen miles an hour is a good strong breeze, but it is not extraordinary. Half our glides in 1902 were made in winds of twenty miles an hour, and at one time we were gliding in a wind which measured thirty-seven miles an hour. You understand, of course, that these gliding experiments do not mean the mere sliding down an inclined plane in the air. In heavy winds the aviator is sometimes lifted above the point he starts from and often held soaring in one place. If he had the balancing skill of a soaring bird, he could remain there as long as there was enough wind to support him. Indeed, in our experiments we have remained motionless in one position for over half a minute.

THE THIRD WRIGHT GLIDER (1902-3)

December 17, 1903, the First Flying-machine Sails

In these three years of gliding we established enough practical knowledge, we thought, to go on to the next experiment of placing a gas-engine upon our aëroplane and starting work on the real object of our research — mechanical flight. In the next year we experimented in our workshop with models and machinery for this. On December 17, 1903, our first mechanical flier, in a trial at Kitty Hawk, made four flights, in the longest of which it sustained itself in the air fifty-nine seconds, and moved 852 feet against a twenty mile wind; that is, it actually moved half a mile through the air. After this first experiment we felt assured that mechanical flight was feasible.

This first flying-machine, with its operator, weighed about 745 pounds. It was run by a gas-engine which weighed 240 pounds complete with fuel and water, and developed 12 or 13 horse-power. The next year another flier was made, weighing, with ballast, 925 pounds, with an engine giving 16 horse-power, but weighing the same as that of the first flier — 240 pounds. With this machine we made the successful experiments in flying of 1904 and 1905, over 150 in number, averaging a mile apiece.

The Trouble Turning Corners

The problem of the real power-driven flying-machine was exactly what we knew it must be — the question of equilibrium. It was no longer necessary for us to have the peculiar conditions furnished by the wind and hills at Kitty Hawk to make our experiments with the mechanical machine. We secured the use of a swampy meadow eight miles east of Dayton, Ohio. On our tests there it became clear that the flying-machine would operate well in a straight line; the difficulty came immediately upon turning corners, as it was necessary to do in the small field. Just what the trouble was we could not tell. Several turns might be made safely; then, all at once, the machine would begin to lose its balance, and must be stopped and brought down to the ground. We kept experimenting to discover the cause of the trouble and the way of dealing with it, and in the latter part of the year 1904 we made some progress. We accomplished a complete circle on September 20, and two flights of three miles each around the course in November and December.

A Practical Working Air-ship

In 1905 we kept making changes in the machine, but made few flights until fall. Finally, about the middle of September, we discovered the way to control the flier in turning corners. The machine was now under practical control. Six flights from September 26 to October 5 averaged over fifteen miles each; on October 5 we obtained a flight of twenty-four miles in thirty-eight minutes, that is, at the rate of thirty-eight miles an hour. As this was on a curved course, the speed would have been over forty miles an hour straight away.

Up to this time we had been able to work and to escape much notice. The local papers were good enough not to print descriptions of our work. There was, in fact, very little understanding locally of what we were trying to do. There was general knowledge that dirigible balloons — like those of Santos-Dumont — were being operated in France, and the local people did not seem to grasp the difference between his experiments and ours. After we had made these long flights we began to attract attention, and we were compelled to give up experimenting in order to keep secret our method of management. We took our machine to pieces and started to plan the 1907 flier. We knew that we had at last secured a practical working aëroplane. Our experiments had been witnessed by a considerable number of reliable men, who constituted a sufficient guaranty that we had made the long flights we claimed, though they did not have technical knowledge enough of mechanics to understand how we made them.

For Sale — An Aërial Warship

We feel that it is absolutely essential for us to keep our method of control a secret. We could patent many points in the machine, and it is possible that we could make a success of the invention commercially. We have been approached by many promoters on the matter. But we believe that our best market is to sell the machine to some government for use in war. To do this, it is necessary for us to keep its construction an absolute secret. We do not believe that this secret can be kept indefinitely by a government, but we believe that the government which has the secret can hold the lead in the use of the invention for years. It will be able constantly to keep ahead of other nations by developing the special knowledge in its possession.

So far as we can learn, we are able now to give a government a five years lead in the development of the flying-machine. The recent trials of Santos-Dumont's aëroplane in France confirm us in this belief. Take one point only. He is trying to sustain a 500-pound machine in the air for short flights with a 50-horse-power engine — that is, sustaining ten pounds to the horse-power. We are flying and carrying, at a rate of 30 miles an hour, 925 pounds with 16 horse-power — that is, practically sixty pounds to the horse-power. The comparison speaks for itself concerning the relative efficiency of the two machines.

Like the Bicycle, but Easier

It is impossible, under these circumstances, for us to discuss the exact secrets of control and management which are our only asset in our machine. We have not even drawn working-plans of our machine, for fear they might fall into other hands. But there are general principles of operating our aëroplane of which we make no secret.

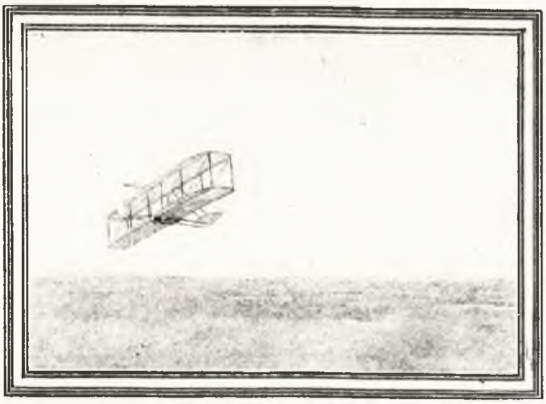
It has been a common aim of experimenters with the aëroplane to solve the problem of equilibrium by some automatic system of balancing. We believe that the control should be left in the possession of the operator. The sense of equilibrium is very delicate and certain. If you lie upon a bed three quarters of an inch out of true, you know it at once. And this sense of equilibrium is just as reliable a mile above the earth as it is on it. The management of our aëroplane, like that of the bicycle, is based upon the sense of equilibrium of the operator. The apparatus for preserving the balance of the machine consists of levers operated by simple uniform movements which readjust the flying surfaces of the machine to the air. The movement of these levers very soon becomes automatic with the aviator, as does the balancing of a bicycle-rider. In fact, the

STARTING A FLIGHT

aëroplane is easier to learn and simpler to operate than the bicycle. In all our experiments with gliding- and flying-machines, we have not even sprained a limb; we have scarcely scratched our flesh.

No Danger from Stopping Engines

The only danger in our aëroplane is of turning over. We have purposely made our machine many times heavier than necessary, so that it cannot break. There is absolutely no danger — as might appear at first thought — from the stopping of the engine. The aëroplane is supported by its motion through the air, it is true; but, however high it is flying, gravity furnishes it all the potential energy it needs to get safely to the ground. When the power is shut off, it merely scales through the air to its landing. Theoretically, it is safer at a mile above the earth than at two hundred feet, because it has a wider choice of places in which to land; you can choose your landing from 256 square miles from a mile above the surface if descending one in sixteen. As a matter of fact, we always shut off the power when we start to alight, and come down by the force of gravity. We reach the ground at so slight an angle and so lightly that it is impossible for the operator to tell by his own sensation within several yards of where the ground was first actually touched.



THE GLIDER TURNING IN THE AIR

The Uses of the Aëroplane

We know that we have made the aëroplane a practical machine, but we are not over-sanguine about its revolutionizing the transportation of the future. It will scarcely displace the railroad or the steamboat; necessarily, its expenditure of fuel will be too great. In a steamship, it is calculated that the heat from the burning of a sheet of letter-paper will carry a ton a mile; you could scarcely expect such results in an air-ship. The air-ship, so far as we can see at present, will have its chief value for warfare, and for reaching inaccessible places — for such uses as expeditions into the Klondike, or to Pekin during its siege a few years ago. The value of an air-ship moving faster than a railroad train for reconnoitering or dropping explosives upon an enemy in time of war is now obvious to the entire civilized world. The aëroplane may also be of great value in the near future for service like the carrying of mail. When properly developed, it will be quicker than any means of locomotion now in use for direct journeys between two places — unless against hurricanes. There will be no switches, no stops whatever; and the journey can be made in an air-line.

Speed Sixty to One Hundred Miles an Hour

The eventual speed of the aëroplane will be easily sixty miles an hour. It will probably be forced up to a hundred miles. Our last machine showed forty miles, and the one we are building now will go considerably faster. At speeds above sixty miles an hour the resistance of the air to the machine will make travel much more expensive of power. Our experiments have shown that a flier designed to carry an aggregate of 745 pounds at 20 miles an hour would require only 8 horse-power, and at 30 miles an hour 12 horse-power. At 60 miles 24 would be needed, and at 120 miles 60 or 75 horse-power. It is clear that there is a certain point of speed beyond which the air resistance makes it impossible to go. Just what that is experiment will determine. Every year gas-engines are being made lighter — a fact which will increase the surplus carrying power of the machine available for fuel and operator and heavier construction; but at present sixty miles an hour can be counted on for the flying-machine. This, of course, means speed through the air.

Fuel for a Thousand Miles

The aëroplane running sixty miles an hour will have surplus lifting power enough to carry fuel for long journeys. Our 1907 machine will carry gasoline enough to fly 500 miles at a rate of some 50 miles an hour. We can, and possibly soon will, make a one-man machine carrying gasoline enough to go 1,000 miles at 40 miles an hour. Moreover, any machine made to move at speeds up to 60 miles an hour can be operated economically, at a cost of not much more than one cent a mile for gasoline.

The aëroplane, while developed originally from the study of the flight of birds, will have a considerably different mechanism for flying. Probably the chief departure comes from the use of the screw-propeller to secure motion. The bird moves forward by sculling with the outer portion of its wings. In some ways this is a more effective mechanism than the screw-propeller, because at each motion the bird secures a grip on new air, while the propeller keeps operating on the stream of air it sets in motion behind it. At the same time, the propeller can go so much faster than any other method of propulsion that it is undoubtedly the device which must be used to propel air-ships.

Better Wings than a Bird's

There is no question but that a man can make a lighter and more efficient wing than a bird's. A cloth surface, for instance, can be produced, offering less surface friction than feathers. The reason for this fact is that a bird's wing is really a compromise. It is not made for flying only — it must be folded up and gotten out of the way when the bird is on its feet; and efficiency in flying must be sacrificed to permit this. The wings of aëroplanes will vary in size according to speed. A slow machine will require a large wing; but the faster the speed, the less will be the supporting surface necessary, and wings for high speeds will naturally be very small. Not only will less support be needed, but the size must be reduced to reduce the friction of the air.

One difficulty with these fast machines will be in launching them at a high enough speed for their wings to support them. There may also be some difficulty in landing. We have launched our machines from an arrangement of wheels, and have landed upon stout skids fastened to the bottom of the machine. The aëroplane will make its journeys, we believe, 200 or 300 feet above the earth — just high enough to escape the effects of the disturbance of the air along the ground — just out of the surf, so to speak. Our experiments have been at a considerably lower level — at some 80 feet or less.

Our idea in our experiments has been to produce a strong, practical motor flying-machine. We have made no great effort to secure extraordinary machinery to furnish power. We found the gas-motor already developed to a point where it was practically available for our purposes. We have applied ourselves to the invention of an aëroplane which would balance safely, could be easily steered, and would move with a moderate expenditure of power. In doing this we have devoted our chief attention to the scientific construction of wings and screws and steering apparatus.

Scientists, not Mechanics

Our hope is, first, to get some adequate financial return from our invention. We are not rich men, and we have devoted our time and what money we could command to the problem for nearly ten years. We do not expect a tremendous fortune from our discovery, but we do feel we should have something that would be an ample competence for men with our comparatively simple tastes. If we do secure this, we are anxious — whenever it becomes possible — to give the world the benefit of the scientific knowledge obtained by our experiments.

We object to the manner in which we have so far been put before the public. Nearly every writer upon our work in current publications has characterized us as mechanics, and taken it for granted — because of the fact that we are in the bicycle business, no doubt — that our invention has come from mechanical skill. We object to this as neither true nor fair. We are not mechanics; we are scientists.

We have approached the subject of aërial navigation in a purely scientific spirit. We are not highly educated men, it is true, but the subject of aërial navigation is not so much a problem of higher mathematics as of general principles; it can be approached by any one possessing a high-school education — which we have had. We have taken up the principles involved in flying, one after another — not only by practical flights, but in constant laboratory experiments in our workshops. We have worked out new tables of the sustaining power of the air.

Discovered Principles of Screw-propeller

Besides inventing a practical flying-machine, we claim to have discovered for the first time the method of calculating in advance the exact efficiency of screw-propellers, which will save the great waste involved in the present practice, by which screws must be made and tested before their efficiency can be accurately learned. This method of ours has been tested in the manufacture of our aëroplanes; our screws were made with only a slight margin of power over what was demanded by our flier, and they have invariably proved successful.

We say frankly that we hope to obtain an ample financial return from our invention; but we care especially for some recognition as scientists, and, whenever it becomes possible, we propose to bring out the results of our investigations in a scientific work upon the principles of aërial navigation.

DEFENDANTS' EXHIBIT "WRIGHT ARTICLE ON ANGLE OF INCIDENCE".

UNITED STATES CIRCUIT COURT
WESTERN DISTRICT NEW YORK.

THE WRIGHT COMPANY,
vs.
THE HERRING-CURTISS CO. and
GLENN H. CURTISS
IN EQUITY #400.

Defendants' Exhibit

"WRIGHT ARTICLE ON ANGLE OF INCIDENCE"

N.Y., Sept. 13/11
Beatrice Mirns
Notary Public,
N.Y.Co. #3049.

parties in the car of each on [illegible] Cardiff, Swansea, Newport, and Pontypridd. Thus it will be seen that there are ample facilities for the future of balloon investigation in this country, and with the ever increasing interest in the subject, no doubt each year of the new century will be able to chronicle further progress.

PERCIVAL SPENCER.

Angle of Incidence.

BY WILBUR WRIGHT.

If the term "angle of incidence," so frequently used in aeronautical discussions, could be confined to a single definite meaning, viz., the angle at which aeroplane and wind actually meet, much error and confusion would be averted. But many of the best writers use this term loosely and inexactly, with the result that their calculations and explanations of phenomena are thereby often rendered of little value, and students are misled.

If a plane be held stationary in a horizontal wind (Fig. 1), the angle of incidence A C D will be equal to the angle with the horizon. But if the wind have an upward trend, the angle of incidence will be increased to A C D^2. A calculation based on the assumption that A C D still remained the true angle would, of course, be seriously in error.

If it be assumed (Fig. 2) that the wind moves from D^2 to C, while the plane moves from E to C, the angle of incidence will become A C D_3. The wind having an apparent horizontal speed of F C+E C, which is equal to F^2 C, as compared with a vertical speed of D^2 F, the wind will appear to strike the plane from the direction D_3 C, thus making its angle of incidence A C D_3 instead of A C D^2.

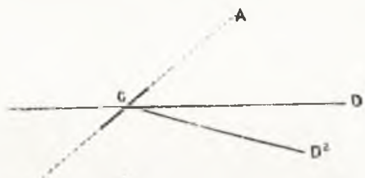


Fig. 1.

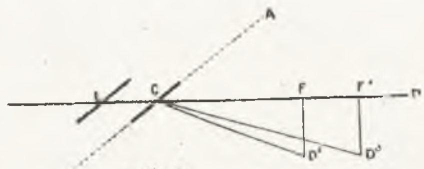


Fig. 2.

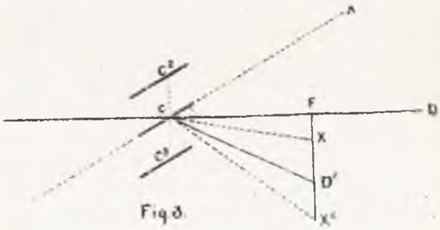


Fig 3.

Taking still another case (Fig. 3), in which the wind moves from D^2 to C, while the plane is rising from C to C^2 the angle of incidence will be A C X. The horizontal speed of the wind will be F C, and its apparent vertical speed D^2 F$-$C C^2 = X F, so that the wind will appear to strike the plane from the direction X C. If the plane had fallen from C to C^3 the angle of incidence would have been A C X^2, since the vertical motion would now have been D^2 F+C C^3 = X^2 F.

A study of the foregoing will lead to the conclusion that in order to obtain the angle of incidence, it is first necessary to know correctly (1) the angle of the plane with the horizon; (2) the horizontal speed of the wind; (3) the vertical speed of the wind; (4) the horizontal speed of the plane; (5) the vertical speed of the plane. Now, since the probability of obtaining five correct simultaneous measurements is very slight when the observation is taken in the open air, and since the soaring angle is not supposed to exceed three degrees, it is evident that calculations based upon observations of soaring birds are of exceedingly doubtful value.

But though direct attempts to calculate the angle of incidence promise little for accuracy, another method remains by which approximately correct results may be obtained. The tables of Langley, Lilienthal, Chanute, and others give with a good degree of accuracy, the vertical component of the normal pressure at all angles and speeds, both for planes and curved surfaces. Now, since the elements of these tables are four, viz., area, speed, angle, and lift, it follows that three factors being known the fourth may readily be obtained. The angle of incidence may be calculated in any case where speed, lift, and area are commensurable. Of these, area may be obtained by actual measurement. Lift is equal to weight supported, and can also be exactly measured. Speed alone requires to be calculated at the instant the observation is made. Thus the opportunity for error is reduced to a single item, and this the one which affects the result least seriously in case of a slight error. It is easier to measure speeds than angles, and errors are less costly. There is, of course, a possibility of error in the tables, but the results have been confirmed by the experiments of independent observers, and are believed to be substantially correct. Calculations of the angle of incidence based upon this plan would scarcely be so seriously in error as that of a well-known writer based upon observations of soaring gulls, in which he obtained from his measurements of angles and speeds an angle of incidence which called for an upward lift of nearly three pounds upon a two-pound bird. It was his idea that the excess of lift was expended in raising the bird above its original level. This, however, is scarcely a satisfactory explanation of how a lift of three pounds could be applied to a two-pound bird in contradiction of the law that action and reaction are always equal. It would be more reasonable to assume that the excessive lift never existed, but that the upward motion of the bird kept the angle of incidence (Fig. 3) reduced to a point where the lift was just equal to the bird's weight all of the time.

If students of aeronautical problems will constantly bear in mind that (1) area of surface; (2) weight or lift; (3) relative speed are the only factors concerned in determining the angle of incidence, many errors will be detected and much trouble saved. It is clear that a bird, instead of possessing full control of its angle of incidence (as writers sometimes assume), is, in fact, almost powerless to change it. The bird is really itself controlled by a kind of automatic governor, for a gust of wind which tends to increase the lift is balked by the fact that the weight of the bird is not sufficient to furnish the required reaction, and the bird must either float back horizontally with a speed equal to the increase in the velocity of the wind, or it will involuntarily be raised at a speed sufficient to keep its angle of incidence at a point where the increased lifting pressure naturally due to the increased speed will be exactly counterbalanced. Nevertheless the bird can, to a limited extent, affect its area, its weight, and its speed, and thus indirectly its angle of incidence also. Its area may be reduced (and its angle increased) by partly folding its wings, but as, in actual practice, a folding of the wings always accompanies an increase of relative velocity (which produces a decrease in angle), the real effect is to preserve the original angle instead of changing it. The apparent weight may be momentarily increased by a sudden curve in the direction of motion, in which case the momentum of its body acts to produce a centrifugal force which increases the downward pressure on its wings, and thus requires an increase in the angle of incidence to furnish the required extra support. Speed may be controlled by increasing or decreasing the elevation of the bird or its rate of fall. But none of these changes in speed, area or weight, quickly and permanently affect its angle of incidence. The bird can at will vary its angle with the horizon, even to the extent of three hundred and sixty degrees in less than a second, as when it turns a complete somersault in the air; but its angle of incidence probably does not vary as much as one-twentieth of that amount in the same case. It is very important to distinguish carefully between the angle of incidence, and the angle with the horizon, as the latter has nothing at all *per se* to do with the former. By keeping the distinction carefully in mind, the student will quickly obtain new ideas of the correct explanation of the action of the Penand tail used by Lilienthal, Pilcher, and Chanute; and correct the sequence of cause and effect in many explanations of phenomena which occur in aeronautical writings.

Since the formulation of a principle into a rule often serves to fix it more prominently in the mind, the writer ventures to offer the following:—

Rule.—The angle of incidence is fixed by area, weight, and speed alone. It varies directly as the weight, and inversely as the area and speed, though not in exact ratio.

The International Balloon Ascents.

April 19th.

The following countries joined in the experiments—Austria, France, Germany, and Russia. The number of balloons sent up were nineteen, of which six were manned. As "Nature" points out in a note upon these International ascents, the results of the ascents with manned balloons from Berlin and Vienna had a very remarkable similitude. At Berlin the temperature on starting was 5°·6 C. and – 25°·5 at an altitude of 5,500 metres; at Vienna it was 5°0 at starting and – 25° at 5,260 metres. The greatest height attained by the ballons sondes was 11,848 metres at Chalais Mendon, where the temperature was – 52°·8 C., the next highest record was 11,000 metres at Trappes where the temperature was – 62°, and the third was 10,500 metres at Strassburg where the temperature was – 54°.

May 14th.

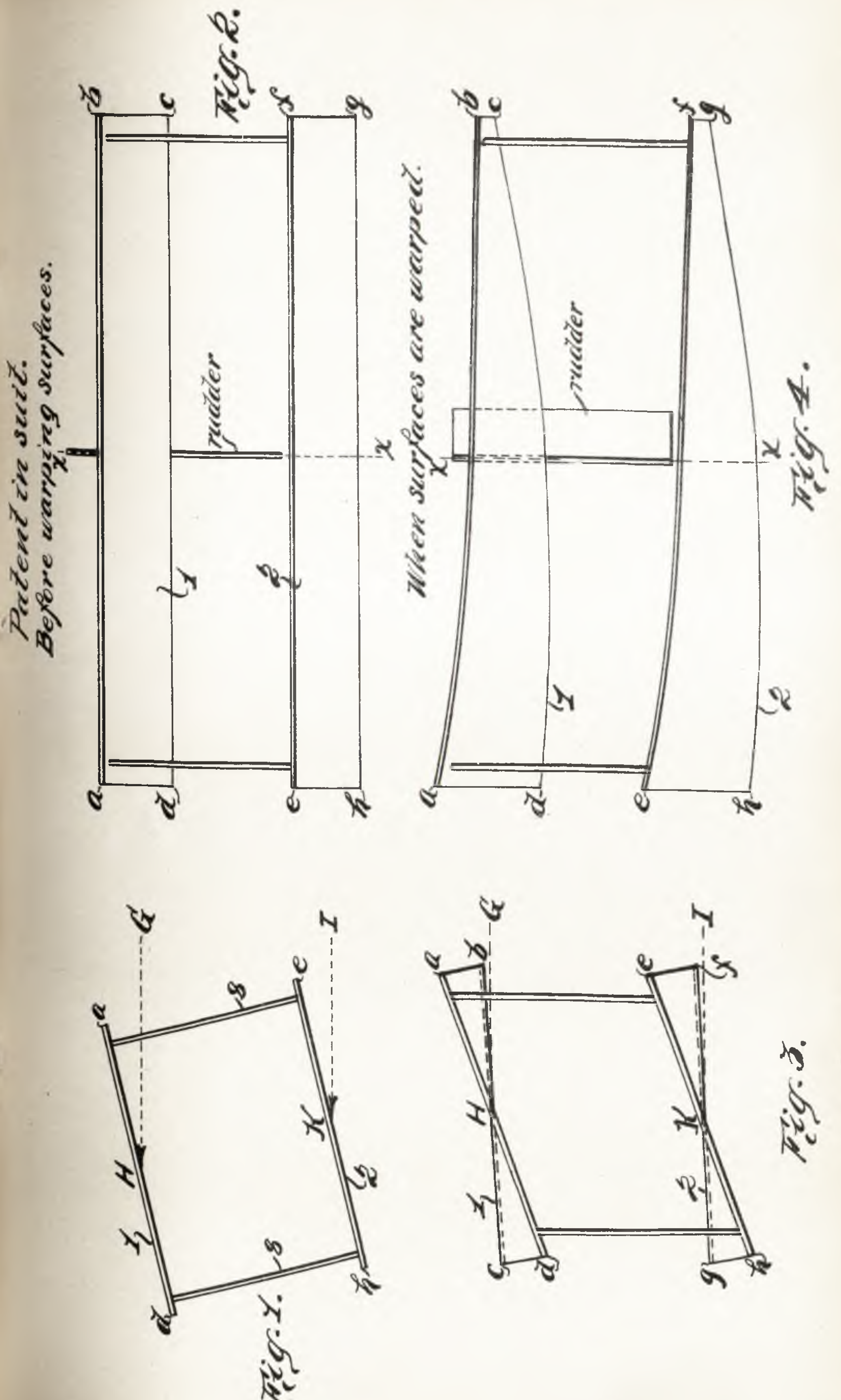
Eighteen balloons were sent up from Berlin, Strassburg, Trappes, Chalais-Mendon and other places. The most interesting result was that of the one sent up from Chalais-Mendon and which has been noted by "Nature." The temperature at starting was 15°·8. Zero was recorded at 3,661 m., – 50° at 9,640 m., and the lowest temperature – 55°·8 at 11,025 m. An invasion of temperature afterwards occurred, and at the highest altitude, 15,414 metres, the thermometer registered – 32°·2.

The absence of ascents from this country is to be regretted, but it may be pointed out that the short period of time during which ballons sondes have been sent up from this country has shown that our insular position is somewhat unfavourable to this method of investigation. A balloon and its recording instruments has already fallen in the sea, though the instruments were recovered. Hence the necessity of having some means of control over the movements of balloons which carry expensive self-recording instruments, when sent up from an island like Great Britain, is apparent. Experimenters are, however, at work, endeavouring to meet the contingency. One attempt is the Meteoparachute, which was brought before the notice of the Society at its last meeting and fully described above. Another, and still later device, is the one being developed by Mr. Patrick Alexander, and which depends upon the action of Hertzian waves for the control of flying machines carrying the instruments. On this interesting new departure Mr. Patrick Alexander will read a paper at the next meeting on the 15th which he promises to illustrate with working models.

NOTES.

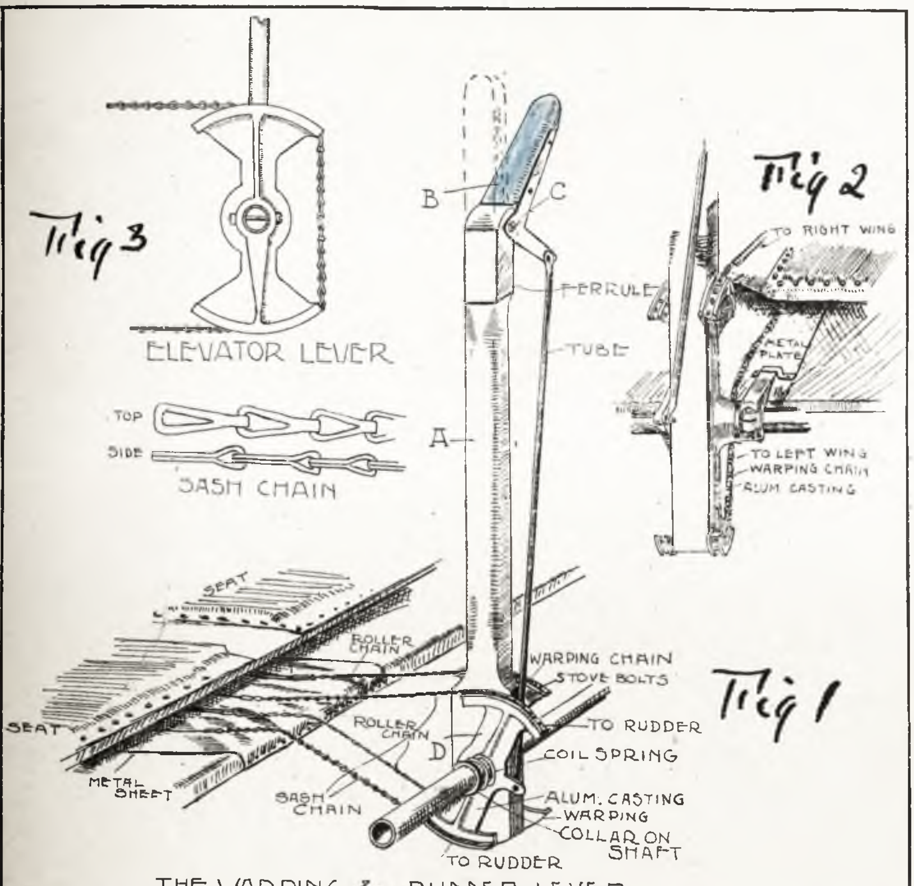
Aeronautical Exhibits at the Crystal Palace Exhibition.—One of the exhibits attracting most attention and interest at the Naval and Military Exhibition now being held at the Crystal Palace, is undoubtedly the Ladysmith balloon. We have before had occasion to call the attention of the public, in the pages of this journal, to the excellent and unique features of our British war balloon equipment, which is, without an exaggeration, the finest in the world. We have also spoken of the satisfactory work accomplished by the balloons during the South African war. In besieged Ladysmith their utility was most specially valued. There, the observer in the car located the enemy's guns, and directed the enemy's fire with an unerring precision. As will be seen in the announcements of the forthcoming general meeting of the Aeronautical Society, a series of views will be presented, showing the operations of the war balloons in different parts of the campaign. Another interesting exhibit at the Crystal Palace is the historic balloon "La Volta," in which M. Janssen, the Parisian astronomer, made his escape during the Siege of Paris. Perhaps this exhibit may be of greater interest to the public on account of the publication

DEFENDANT'S EXHIBIT. SKETCH No. 1



Defendants' Exhibit
DRAWING PRESENT WRIGHT
WARPING LEVER.

AERONAUTICS



THE WARPING & RUDDER LEVER

WRIGHT 1042

DEFENDANTS' EXHIBIT, "File Wrapper and Contents Wright Patent in Suit, No. 821,393".

UNITED STATES CIRCUIT COURT
WESTERN DISTRICT NEW YORK

ORVILLE WRIGHT & WILBUR WRIGHT
vs.
HERRING-CURTISS COMPANY
and
GLENN H. CURTISS
In Equity #400[illegible]

Defendant's Exhibit

FILE WRAPPER & CONTENTS
WRIGHT PATENT IN SUIT.

Beatrice Minns
Notary Public
N. Y. Co

THIS IS TO CERTIFY that the annexed is a true copy from the Records of this Office of the File Wrapper and Contents in the matter of the

Letters Patent of

Orville Wright and Wilbur Wright,

Number 821,393, granted May 22, 1906,

for

Improvement in Flying-Machines.

U. S. CIRCUIT COURT,
WESTERN DIST. OF N. Y.
FILED

DEC 14 1909

HARRIS S. WILLIAMS,
CLERK.

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this 10th. day of November, in the year of our Lord one thousand nine hundred and nine and of the Independence of the United States of America the one hundred and thirty-fourth.

F. A. Tennant

I-2 Assistant. Commissioner of Patents.

$15 RECEIVED
MAR 14 1903
CHIEF CLERK,
U. S. PATENT OFFICE.

Stamp Cancelled T. C.
Paper Canceled.

Serial No. 149220 Paper No. 1/2
Application
Filed Mar. 23, 1903.

Wright & Wright

MAIL ROOM
MAR 23 1903
U. S. PATENT OFFICE.

B

PETITION.

To the Commissioner of Patents:

Your petitioners, Orville Wright and Wilbur Wright, citizens of the United States, residing at Dayton, in the County of Montgomery, and State of Ohio, the post office address of both of whom is 1127 West Third Street, Dayton, Ohio July 13/04 pray that letters patent be granted to them, as joint inventors, for the improvement in Flying Machines set forth in the annexed specification.

Signed at Dayton, in the County of Montgomery, State of Ohio, this 9th day of March, 1903.

14 Claims

Orville Wright.

Wilbur Wright.

U. S. Patent Office,
MAR 25 1903
Division XXVIII.

2

SPECIFICATION.

Cancelled per Sub Spec Augt. 17/05

To all whom it may concern:

Be it known that we Orville Wright and Wilbur Wright, both citizens of the United States, residing in the city of Dayton and state of Ohio, have jointly invented a new and useful machine for navigating the air, of which the following is a specification:

Our invention relates to improvements in that class or aeronautical machines in which the weight is sustained by the reactions resulting when thin surfaces, or wings, are moved horizontally almost edgewise through the air at a small angle of incidence, either by the application of mechanical power, or by the utilization of the force of gravity.

The objects of our invention are, first, to provide a structure combining lightness, strength, convenience of construction, and the least possible edge resistance; second, to provide means for maintaining or restoring the equilibrium of the apparatus; and, third, to provide efficient means of guiding the machine in both vertical and horizontal directions. We obtain these objects by the mechanism shown in the accompanying drawing, in which Figure 1 is a view in perspective of the machine; Figure 2, a side elevation; and Figure 3 , a top plan view.

The superposed horizontal surfaces A, A, formed by stretching cloth upon frames of wood and wire, constitute the "wings", or supporting part of the apparatus. They are connected to each other through hinge joints by the upright standards B, B' and the lateral stay wires C, C', which, together with the lateral spars D, D' of the wing framing, form truss systems giving the whole machine great transverse rigidity and strength. The hinge joints admit of both flexing and twisting movements, and may be either ball and socket joints, or any joint of sufficiently loose construction to admit of the movements specified. The object of joints having both flexing and twisting movements is to permit superposed wing~~s~~ surfaces, or parts thereof, when joined together by upright standards, to be twisted or bent out of their normal planes for the purpose hereafter specified. We do not restrict ourselves to the use of any particular form of joint, nor to its use at any particular number of places.

One end of the rope F is attached near the rear corner of the upper surface, passes diagonally downward around the pulleys I, I, and diagonally upward to the corresponding corner at the opposite end of the machine. The rope H is attached to the front corner of the upper surface, passes around the pulleys I', I' and back to the opposite upper corner. The moveable cradle J is attached to the rope F at the point where the operator's body rests, and provides a means of imparting movement to the ropes F and H. The operator liesprone on the lower surface, his hips resting in the cradle, and his hands grasping the roller g, which actuates the front rudder. The ropes F and H maintain the fore and aft positions of the two surfaces A, A with respect to each other, and by their movement impart a twist to the entire structure, including the wings A, A, as will be more fully described hereafter. We have shown the operating system by means of ropes, which we now prefer to use, but we do not restrict ourselves to the use of any particular method of imparting this twist to a structure formed in the manner specified.

The main frames of the wings A, A are formed by uniting the lateral spars D, D' (Fig. 3) by means of end bows K, K. The cloth for each wing, previous to its attachment to the frame, is cut on the bias and made up into a single piece approximately the size and shape of the wing, having the threads of the cloth 1 (Fig. 3) diagonal to the lateral spars D, D' and the longitudinal ribs o,o, with which they form truss systems. A wide hem is sewed in the rear edge to form a pocket for the insertion of the wire m. By the combination of a frame work with a cloth covering, each formed in the manner described, we secure a surface of very great strength to withstand lateral and longitudinal strains, but capable of some twisting movement.

When the two surfaces A, A are joined together by the wire stays C, C', the ropes F and H, and the upright standards B, B' as already described, a system is formed capable of sustaining great weight without distortion. But when the cradle J is moved to right or left by the operator, the motion is communicated through the ropes F and H and the upright standards B, B' in such a manner that the wing surfaces are twisted, the rear edge of the wing tips being drawn downward at one end of the machine and drawn upward at the other; thus presenting the left set of wing tips to the wind at a greater or a less angle than the right. When in flight, the end having the greaterangle will necessarily rise and the other end will sink, so that the lateral balance of the machine is under control through twisting movements of the wing tips by the operator, by means of the cradle J.

The struts P, P, together with the struts R, R, (Fig. 2) in combination with the main frame, form trussed skids which prevent the machine from rolling over forward when it lands, and also relieves the jerk on the rope H. They are also utilized as a part of the front rudder steering system.

The flexible front rudder S consists of the stiff cross sticks a, c, d and the thin ribs b, over which is stretched a cloth covering. The rudder is mounted upon the struts P, P by attachment to the cross stick a, which is located near the center of pressure, so as to form a balanced rudder. The up and down motion of the front edge of the rudder is in part restrained by the springs f, f. The rear edge is raised and lowered by means of the axles g, g', the bands h and the arms i, i, or by any other suitable means. The restraining action of the springs f, f causes the ribs b, b to bend when the rear edge is raisedor lowered, thus presenting a concave surface to the action of the wind, and very greatly increasing its power as compared with a plane of equal area. By regulating the pressure on the upper and lower sides of the rudder, through changes of angle and curvature, a turning movement is communicated to the main structure and the course of the machine is directed upward or downward at the will of the operator, and the longitudinal balance maintained.

Contrary to the usual custom, we place the horizontal rudder in front of the main surfaces or "wings" at a negative angle, and use no horizontal tail at all. By this arrangement we obtain a forward surface which is almost free from pressure under ordinary conditions of flight, but which, even if not moved at all, becomes an efficient lifting surface whenever the speed of the machine is accidentally reduced very much below the normal, and thus largely counteracts that backward travel of the center of pressure on the main surfaces or wings which has frequently been productive of series injuries, by causing the machine to turn downward and strike the ground head on. We are aware that a forward horizontal rudder of different construction has been used in combination with a supporting surface and a rear horizontal rudder, but this combination was not intended to effect and did not effect the object which we obtain by the arrangement of surfaces here described.

The vertical tail or rudder L is attached through universal joints to the two pairs of struts k, k which lie in parallel horizontal planes, and are connected to the rear edges of the main surfaces A, A by hinged joints. This combination secures the tail rigidly in a vertical position, but enables it to turn on a vertical axis, and also to rise bodily in case it strikes the ground, and thus escapes breakage. The cords r, r are tiller ropes which connect the rudder wheel t to the rope H, which in conjunction with the rope F imparts the twisting motion to the wing tips as heretofore described. By this method of attachment the same motion of the ropes H and F which actuates the wing tips also presents to the wind that side of the vertical rear rudder which is toward the tip having the smaller angle of incidence. The wing tip presented to the wind at the greater angle, under the usual conditions of flight, has both greater lift and greater drift, or resistance, than the other. The wing with the greater angle therefore tends to rise and drop behind, while the other sinks and moves ahead. Under these circumstances the longitudinal axis of the machine tends to turn toward the wing having the greater angle, while the general course of the machine through the air tends toward that wing which is the lowest, with the result that a wide divergence soon arises between the direction which the machine faces and its actual direction of travel. By the use of a rear moveable vertical rudder, so operated as to present to the wind that side which is toward the wing having the least angle, we obtain a turning force opposite to and greater than that arising from the difference in the resistance of the two wings, and thus are able to keep the longitudinal axis of the machine approximately in coincidence with the line of flight. We do not confine ourselves to the particular construction and attachment of the rear rudder hereinbefore described, nor to this particular construction of surfaces or wings, but may employ this combination in the use of any moveable vertical rear rudder operated in conjunction with any wings capable of being presented to the wind at respectively differing angles at their opposite tips for the purpose of restoring the lateral balance of ~~the machine~~ a flying machine and guiding the machine to right or left.

We are aware that prior to our invention flying machines have been constructed having superposed wings in combination with horizontal and vertical rudders, we therefore do not claim such combination broadly, but what we do claim as our invention and desire to secure by Letters patent, is,

Sub. A
July 13/04

1. In a flying machine the combination of superposed surfaces or "wings" with upright connecting standards, one or more of which has its attachment by means of hinges or flexible joints, substantially as described and for the purpose specified.

2. In a flying machine the combination of superposed surfaces or wings with upright connecting standards attached through flexible joints and laterally extending stay wires, substantially as described.

3. In a flying machine the combination of one or more supporting surfaces or wings with a device for imparting a twist to the said surfaces or wings for the purpose stated.

4. In a flying machine the combination of superposedwings, upright standards attached by flexible joints, and laterally extending stay wires, with a device for imparting a twisting to the

wings for the purpose specified.

5. In a flying machine the combination of superposed wings, upright standards attached by means of flexible joints, and laterally extending stay wires, with actuating ropes attached and operated substantially as described.

6. In a flying machine the combination of wings having their right and left tips capable of being adjusted so as to be presented to the wind at respectively differing angles, with a vertical adjustable rear rudder operating in conjunction therewith in the manner and for the purpose specified.

7. In a flying machine having wings capable of being twisted by actuating ropes, the combination therewith of a moveable vertical rear rudder having tiller cords attached to said actuating ropes substantially as described.

8. In a flying machine the combination of superposed surfaces with a vertical rear rudder, and hinged connecting arms in parallel planes, substantially as described.

9. In a flying machine having surfaces or wings composed of a cloth covered frame, the combination of laterally extending spars and longitudinal ribs, with a covering having the threads of the cloth diagonal to the main lines of the framing, substantially as set forth.

10. In a flying machine the combination of superposed surfaces with forwardly extending struts arranged in the manner and for the purposes specified.

11. In a flying machine the combination of supporting wings with a smaller inert front surface which becomes a supporting surface when the speed of the machine is greatly diminished, substantially as described and for the purpose specified.

12. In a flying machine the combination of supporting wings and a horizontal rudder, having stiff lateral ~~ribs~~ sticks, thin longitudinal ribs, and cloth covering, and a device for imparting a slight curvature to the rudder in the manner and for the purpose specified.

13. In a flying machine the combination of supporting wings with a flexible horizontal rudder and a device for simultaneously regulating the angle of the rudder with the windand imparting to it a slight curvature, substantially as described and for the purpose specified.

14. In a flying machine the combination of superposed surfaces capable of being twisted with a forward horizontal rudder and an adjustable vertical rear rudder, substantially as described and for the purposes specified.

Orville Wright.

Wilbur Wright.

Chas. E. Taylor.

E Earle Forrer.

OATH.

State of Ohio)
County of Montgomery) ss:

Orville Wright and Wilbur Wright, the above named petitioners, citizens of the United States, and resident of Dayton in the County of Montgomery and State of Ohio, being duly sworn, depose and say that they verily believe themselves to be the original, first, and joint inventors of the improvement in Flying Machines described and claimed in the foregoing specification; that the same has not been patented to themselves or to others, with their knowledge or consent, in any country; that the same has not to their knowledge been in public use or on sale in the United States for more than two years prior to this application, and they do not know and do not believe that the same was ever known or ever used prior to their invention thereof.

Orville Wright
Wilbur Wright

Sworn to and subscribed before me, this 9th day of March, ~~19~~ 1903.

J R Thomson
Notary Public
Montgomery County
Ohio

(NOTARIAL SEAL)

My Commission
Expires April 17th 1903

OATH.

TO ACCOMPANY AN APPLICATION FOR UNITED STATES PATENT.

State of Ohio)
ss: R
County of Montgomery)

Orville Wright and Wilbur Wright the above-named petitioners, being sworn (or affirmed) depose and say that they are citizens of the United States and residents of No. 7 Hawthorne St, in the city of Dayton, County of Montgomery and State of Ohio, that they verily believe themselves to be the original, first, and joint inventors of the improvement in Flying Machines described and claimed in the annexed specification, Filed, March, 14, 1903, that they do not know and do not believe that the same was ever known or used before their invention or discovery thereof, or patented or described in any printed publication in any country before their invention or discovery thereof, or more than two years prior to this application, or in public use or on sale in the United States for more than two years prior to this application; and that no application for patent on said improvement has been filed by them or their representatives or assigns in any country foreign to the United States, ~~except as follows~~:

Orville Wright

Wilbur Wright.

Sworn to and subscribed before me this 19th day of March, 1903

J R Thomson

Notary Public

(NOTARIAL SEAL) 13 Montgomery County

0

THIS MEMORANDUM SHOULD UNDER NO CIRCUMSTANCES BE DESTROYED OR OTHERWISE PERMANENTLY REMOVED FROM THE FILE.

Application of Wright & Wright.

for

received incomplete

Petition:

Oath: Papersret. for formal oath. blank form sent. Mar. 16, 1903

Specification:

Drawing:

Fee:

General:

The following are the numbers of the Chief Clerk's letters relating to this case:

(1) *(4)*

(2) *(5)*

(3) *(6)*

2-260.

Div.______ Room No. 218. M.———— Rej. Paper No. 1.

All communications should be addressed to "The Commissioner of Patents, Washington, D. C."

All communications respecting this application should give the serial number, date of filing, and title of invention.

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., April 28, 1903.

Orville Wright, et.al., MAILED " " "

Dayton,

Ohio.

Please find below a communication from the **EXAMINER** *in charge of your application,* Flying Machines, filed March 23, 1903, Serial #149,220.

F. I. Allen,

XXXXXXXXXX

Commissioner of Patents.

This case has been examined.

The drawing has been condemned by the Office Draftsman on account of its pale lines.

The applicants' P. O. addresses should be stated in the Petition.

NO C' is found on the drawing.

The claims are so vague and indefinite as to be but uncertainly comprehended.

The first 6 claims do not define anything over and are rejected on; -

#220,473, Greenough, Oct. 14, 1879;
#397,647, Holmes, Feb. 12, 1889;
#542,100, De Los Olivos, July 2, 1895;
#606,187, Butusov, June 28, 1898;
#133,046, McDermott, Nov. 12, 1872;

or the German patent, #84,949, Rentzsch.

Claim 7 is rejected on the same references. The Examiner is unable to understand the alleged result attained by connecting the rudder to the wing ropes and so far as he is able to judge the claim involves nothing over the references except a mere matter of taste.

Claim 8 is rejected as an aggregation. There is no relation between the superposed surfaces and a rudder with hinged connecting arms. The claim is also rejected on Butsov. It is a mere matter of taste whether the rudder G is hung on hinged arms or otherwise.

Claim 9 is rejected on the references already cited. It distinguishes from them merely in the specific manner of applying the cloth to the frames which is a matter of mere choice or judgment.

Claim 10 is too vague to define anything at all.

The same is true of claim 11. It is rejected, in so far as understood, on the British patent, #8,320, Tarczal, April 23, 1901.

Claim 12 is rejected on Butusov, or Greenough.

Claim 13 is so far as understood is also rejected on these patents.

Claim 14 is rejected on Tarczal, in view of Butusov, or Greenough.

The claims are furthermore all rejected as based upon a device that is inoperative or incapable of performing its intended function. The Examiner is unable to understand how the machine is supposed to operate. In order to understand the so called twisting of the surfaces and the relation between this and the movements of the rudder a model would be useful if not absolutely necessary. It is not understood either whence the machine is supposed to derive its ascentional power. In the absence of a gas field and of any indication of means for enabling the machine to rise it must necessarily be held inoperative as an air ship, while if intended merely as a soaring machine or parachute it should be plainly indicated in the specification.

H.R.B.

W. W. Townsend
Ex .

Serial No. 149220 Paper No. 2
Letter to Office.
Filed May 6, 1903

U.S. Patent Office,
MAY 7 1903
Division XXVIII.

Wright & Wright

14 Claims

Dayton, Ohio May 4, 1903.

MAIL ROOM
MAY 6 1903
U. S. PATENT OFFICE.

The Commissioner of Patents,

Washington, D. C.

Your communication of April 28,,1903, relating to our application Flying Machines, filed March 23, 1903, Serial # 149,220 is received.

The informalities in the drawing and petition will be corrected.

The stays C' were omitted from the drawing because their insertion would to some extent make the nature of the structure more difficult to grasp at a brief examination,owing to the increased confusion resulting from multiplicity of lines. We will either insert the stays C' in the drawing, or, amend the specification by stating that the stays C' are omitted from the drawing to avoid confusion, but that they bear the same relation to the spars D' and the uprights B' that the stays C bear to D and B, as the examiner may elect.

An error in the lettering of Fig. 2, whereby the rear uprights are marked B instead of B' will also be corrected.

The patents which have been cited in general as ground for the rejection of our claims have been examined, but we are entirely unable to comprehend the pertinence of the references. We therefore request that the particular claims in the patents cited which anticipate our claims be specified and the respect in which there is conflict be explained.

The twist imparted to the surfaces, which the examiner does not seem to understand fully, may be also defined as a warp. Its nature is clearly defined in Webster's International dictionary under the titles warped surface and helicoid. The twist is in the surface itself, and ~~it~~ has no reference to a variation in the angular inclination of a plane to a car or body suspended beneath it. If the little square tube or cardboard which we send under another cover be diagonally compressed at one end between thumb and finger, the walls will assume the ~~walls will~~ twist to which reference is had, and a study of it as viewed from the front and also from the end may be more satisfactory to the examiner than dictionary definitions. Once the nature of this twist is comprehendedthe examiner should have no further difficulty in understanding the operations and relations of the various parts of the machine from the drawings and specifications. We feel certain that any person skilled in the art would be able from the description ~~be~~ to build a machine and understand its operation when completed.

/s Respectfully,

Orville Wright

Wilbur Wright

2—260.

Div.......... Room...No. 382. M. Letter, Paper No. ...3.

All communications should be addressed to "The Commissioner of Patents, Washington, D. C."

All communications respecting this application should give the serial number, date of filing, and title of invention.

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., July 14, 1903

Orville Wright et.al., MAILED " " "

Dayton,

Ohio.

Please find below a communication from the EXAMINER in charge of your application,
Flying Machine, filed March 23, 1903, Serial #149,220.

F.I.Allen,

x E. B. Moore

Commissioner of Patents.

This case has been further considered in connection with the letter of May 6, 1903.

The applicants' post office addresses have not been supplied nor the drawing corrected in respect to its pale lines.

The stays C' must either be shown on the drawing or the reference letter C' erased from the description, whichever the applicant may prefer.

The card board exhibit filed in this case is of no assistance and the examiner is still unable to understand the operation of the device.

The specification is too vague to indicate whether the apparatus is intended to be used as a soaring machine merely, or as an air ship, but so far as seen it is inoperative for either purpose. There is no way disclosed in which the apparatus can rise in the air and propel itself as an air ship or get its start as a soarer. The operator cannot run with the machine to give it a start and climb aboard after launching it, and if he places himself in position while the machine is on the ground it does not appear how machine and operator are to get off the ground. Until the operativeness of the device is shown, which can best be accomplished by a working model, the claims stand rejected for inoperativeness.

They stand further rejected on the other grounds and reasons of

1864 record. In regard to the rejection on references the applicant appears to be under a misapprehension both as to the force of the references and the duty of the examiner. In the first place the force and scope of a patent as a reference, is not limited by its claims. If the device covered by a given claim is described or shown in a patent it is anticipated by the patent whether it be claimed therein or not. In the next place when claims are rejected on references it is the applicants' duty, in asking for reconsideration to point out wherein his claims avoid the references. For example, taking claim 1 of the present case, all that is involved in this claim are "surfaces" connected by uprights by means of hinges or flexible joints. In Greenough are found surfaces a and f connected by upright h having hinged joints.

Claim 2 is the same as 1 with the addition of side stays l.

Claims 3- 5 involve the same elements as 1 and 2, with the addition of actuating ropes l' and p.

Claim 6 involves nothing but the wing a and tail t of Greenough or wings D and rudder H of Butusov.

Claim 7 as far as the examiner can see involves nothing over the references except matters of taste. If any one wishes to tie the cords that operate the rudder of Greenough or Butusov to the ropes that operate the wings it is an obvious matter to do so. The examiner does not see why any one should care to arrange the cords so but neither is there any reason for it in the case of the claim.

The grounds of rejection of claims 8 to 11, inclusive, are fully explained in the former letter.

Claim 12 is substantially anticipated by the wings and rudders of Greenough, or Butusov.

Claim 13 is met by the wings and rudders and the springs attached to the rudders of Greenough, and Butusov.

Claim 14 involves merely the application of a horizontal rudder to the front in place of the rear of Butusov, which in view of Tarczal involves no invention.

If the applicant does not perceive the pertinence of the references he should point out exactly wherein he considers his claims avoids these references that the examiner may know what further explanation is necessary. (See ex parte Henderson 91 O. G., 228).

The applicants are advised in case of further proceedings to employ an attorney skilled in patent practice.

H.R.B. W. W. Townsend

Ex

MAIL ROOM
FEB 18 1904
U. S. PATENT OFFICE.

Springfield, Ohio Feb. 16, 1904.

Hon. Commissioner of Patents,

Washington, D. C.

Sir: —

We enclose herewith a power of attorney in the matter of the application of Wright and Wright, for improvement in Flying Machines, filed March 23, 1903, Ser. No. 149,220. When we wrote our letter of Feb. 8, No. 27,520 referred to in your communication of the 11th inst., we supposed that this power had been already filed.

Very respectfully,

Dict.

H. A. Toulmin

MAIL ROOM FEB 18 1904 U. S. PATENT OFFICE. DOCKET CLERK FEB 18 1904 U. S. PATENT OFFICE. Serial No. 149,220 Paper No. 4 Power of Atty

To the Commissioner of Patents,

Sir:

The undersigned, having on March 23, 1903, filed an application for Letters Patent of the United States, for improvements in Flying Machines, Serial No. 149,220, hereby appoint Harry Aubry Toulmin, of Springfield, Ohio, their attorney, with full power of substitution and revocation, to prosecute said application, to make alterations and amendments therein, to receive the Letters Patent, and to transact all business in the Patent Office connected therewith.

Signed at Dayton, in the County of Montgomery, and State of Ohio, this 15th day of February, 1904.

Orville Wright

Wilbur Wright

MAIL ROOM JUL 13 1904 U. S. PATENT OFFICE. U. S. Patent Office, JUL 14 1904 Division XXVIII. Serial No. 149220 Paper No. 5 Amendment. A Filed July 13, 1904

Wright & Wright

IN THE UNITED STATES PATENT OFFICE.

Application of Room 382.

Orville & Wilbur Wright,

Flying Machines,

Filed March 23rd, 1903,

Ser. No. 149,220.

Hon. Commissioner of Patents,

Sir:-

Amendment is hereby made as follows:-

In the proper place in the petition, insert the words "the postoffice address of both of whom is 1127 West Third Street, Dayton, Ohio,"

Cancelled Jany 13/05

Cancel the claims and substitute the following:-

A (1) In a flying machine, the combination, with two normally parallel aeroplanes substantially rectangular and superposed the one above the other, of upright standards connecting said planes at their margins, the connections between the standards and planes at the lateral extremities of the planes being by means of flexible joints, substantially as described.

(2) In a flying machine, a normally flat aeroplane having lateral margins, in combination with means for simultaneously moving said margins into different angular positions to the normal plane of the aeroplane, substantially as described.

(3) In a flying machine, the combination of parallel superposed aeroplanes, each having lateral margins, uprights connecting said aeroplanes at their edges, the uprights connecting the lateral

margins of the aeroplanes being connected with said aeroplanes by flexible joints, and means for simultaneously imparting to the lateral margins of said aeroplanes different angular positions relatively to the normal planes of said aeroplanes, substantially as described.

(4) In a flying machine, an aeroplane having substantially the form of a transversely elongated rectangle and normally flat, in combination with means for imparting a twist to said aeroplane around its longer axis, whereby the lateral margins thereof are moved into different angular relations to the normal plane thereof, substantially as described.

(5) In a flying machine, the combination, with two superposed and normally parallel aeroplanes, having the form of laterally elongated rectangles, and upright standards connecting the edges of said aeroplanes to maintain their equidistance, those standards at the ends or lateral margins of said aeroplanesbeing connected therewith by flexible joints, of means for simultaneously imparting to said aeroplanesa twist around their central longitudinal axes, whereby the lateral margins of said aeroplanes are moved to different angular relations to the normal planes thereof, substantially as described.

(6) In a flying machine, the combination, with one or more aeroplanes, and means for simultaneously moving the lateral edges of said aeroplane or aeroplanes into differentangular relations to the normal plane or planesthereof, of a vertical rudder, and means whereby said rudder presents to the wind that side thereof nearest the end of the aeroplane having the smaller angle of inci-

dence, substantially as described.

(7) In a flying machine, the combination, with one or more aeroplanes, of a normally flat and horizontal flexible rudder, and means for curving said rudder rearwardly and upwardly or rearwardly and downwardly with respect to its normal plane, substantially as described.

(8) A flying machine comprising superposed aeroplanes, means for moving the opposite lateral ends of said planes to different angles, a vertical rudder, means for moving said vertical rudder toward that end of the aeroplanes presenting the smallest angle of incidence, and a flexible horizontal rudder provided with means for curving it upward and rearward or downward and rearward from itsnormal plane, substantially as described.

Note:-

Since the applicants have given a power of attorney to their present attorney, he has been engaged in the preparation and prosecution of numerous foreign applications on this structure, and has reserved the amendment of this application until in possession of the prior art as disclosed by said foreign applications. It is proposed to furnish a new drawing which will meet the views of the chief draftsman and of the examiner, and to entirely rewrite the descriptive portion of the specification in connection with the entire prior art as thus disclosed and the features of novelty hereafter determined to be patentable.

In the meantime, some further explanation of the main features of the structure will doubtless enable the examiner to differentiate the claims now presented from the prior art of record.

It should first be stated that the structure which forms the subject-matter of this application is capable of use both as a soaring machine and as a flying machine, and has been successfully used in both forms. The enclosed pamphlet will give the examiner some information as to its use as a soaring machine, and it may be stated that experiments with the same apparatus, with the addition of a suitable motor and propelling devices, have been going on for several months past and have been quite successful.

The examiner has apparently failed to understand applicants' explanation of the twisting of the planes, and in this connection the following further explanation is offered. If the examiner will look at Fig. 2 of the drawings and assume that the cradle J is moved to the right in Fig. 1, or away from him in Fig. 2, he will see that, through the pull on the cord F at the end nearest to him, the standard B at the rear will move downward and the standard B at the front will move upward at the end nearest to him in Fig. 2. This will place the lateral edges of the planes A nearest him in Fig. 2 in a position with their front ends elevated and their rear ends depressed. At the same time, the opposite effect will be obtained at the opposite extremities of the planes A, so that looking along either plane lengthwise thereof, it will be seen to be twisted spirally around its central longitudinal axis. Absolutely nothing of this sort is disclosed in any of the references, and it constitutes a new method of maintaining the horizontality or equilibrium of the structure as a whole. In other words, the lateral balance of the machine is controlled by this twisting of the ends thereof as contradistinguished from the method usually employed of shifting a weight for this purpose. The reenough patent, and others of that type cited, employ a rigid plane which tilts as a whole, none of them being provided with means for controlling the angular position of the lateral margins so as to present them to the wind at different angles. This is the main feature of applicants' invention, and as a means for attaining this end, the further feature of connecting the planes by uprights, of which the end ones at least are connected to both planes by flexible joints, is employed. This feature also is entirely lacking in the references.

As to the vertical rudder, it is in no sense a steering device, but is simply for correcting the increased resistance offered by one end of the machine over the other arising from the different angles at which the ends of the planes are presented to the wind, and this it does automatically in a manner nowise suggested by any of the references, none of which disclosed a structure even requiring such a device, much less the device itself.

As to the horizontal rudder, thepoint of novelty here lies in the fact that the rudder can be so bent as to present a curved surface extending either rearwardly and upwardly or rearwardly and downwardly from the normal plane of the rudder. It thus presents at will either a concave upper surface or a concave lower surface, and the experiments of Lillienthal, Maxim and others have shown conclusively that when a concave surface is struck by the wind, the pressure at small angles is many times greater than if the surface is flat or convex on that side. The horizontal rudder is thus rendered much more sensitive and delicate and is capable of presenting a concave side to the wind in all cases,

28

whether the wind strikes the upper or lower side. Nothing of this sort is disclosed in any of the references cited.

In view of the foregoing, it is respectfully urged that the claims now presented clearly distinguish from the prior art of record and that applicants are entitled to an allowance of the same. As already stated, the drawings and specification will be revisedto meet the examiner's views.

Respectfully submitted,

29

H. A. Toulmin
Attorney for Applicants.

Springfield, Ohio,
July 11th, 1904.

2--260.

Div. 28. Room 382. M. Rej. Paper No. 6.

All communications should be addressed to "The Commissioner of Patents, Washington, D. C."

All communications respecting this application should give the serial number, date of filing, and title of invention.

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

3

WASHINGTON, D. C., November 8, 1904.

Wright & Wright, MAILED " " "

C/o Harry A. Toulmin,

Springfield,

Ohio.

Please find below a communication from the EXAMINER in charge of your application,
Flying Machines, filed March 23, 1903, Serial #149,220.

F. I. Allen

XXXX

Commissioner of Patents.

This case, as amended July 13 1904, hasbeen considered.

Claim 1 is rejected. It doesnot involve anything patentable over such aeroplanes as, for example, that shown in the British patent Moy, #15,221, June 25, 1897.

The flexible connections do not, in themselves, constitute a patentable distinction, for, without means for shifting the planes and holding them in different relative positions, it is a mere matter of taste whether they are flexible or rigid.

Claim 2 is rejected on Butusov or,-

#338,173, Jongewaard, March 16, 1886;
#728,844, Boswell, May 26, 1903;

The first two have planes normally flat and Boswell is practically so, while all of them have means for moving the margins into different angular positions.

Claim 3 is rejected on Richmond.

Claims 4 and 5 are thought to be lacking in foundation. In so far as the effect upon the aeroplanesof a pull upon the linesF can be traced upon the drawing it does not seem to be accurately expressed as "a twist around its longitudinal axis". It is noted also that the expression "transversely elongated", is obscure. It doesnot appear with respect to what it is transversely elongated.

It is suggested that the objections to claim 4 might be removed without in any wise restricting its scope by amending it to read, "an aeroplane having substantially the form of a normally flat rectangle elongated transversely of the line of flight, in combination with means for imparting to the lateral margins of said aeroplane a movement about an axis perpendicular thereto and for moving them into different angular relations to the normal plane thereof".

The objection to claim 5 might be removed by a similar amendment.

Claim 6 is rejected as alternative in itself and vague and indefinite. There is no relation disclosed between the aeroplanes in case there are more than one. It does not appear whether they are side by side, or end to end, or one above another, or in any other of the various relative positions they may assume. Also it is not clear what is meant by having the "smaller angle of incidence".

Claim 7 is alternative in form and vague in the matter of "one or more aeroplanes".

Claim 8 should state with respect to what the ends assume different angles.

The remarks of the attorney concerning a new specification and drawing is noted and it is assumed that they will be free from the objections noted against the originals and afford the necessary foundation for the claims.

31

H.R.B.

W. W. Townsend
Ex

MAIL ROOM JAN 13 1905 U. S. PATENT OFFICE.

U. S. Patent Office, JAN 13 1905 DIVISION XXVIII.

Serial No. 149220 Paper No. 7
Amendment. B
Filed Jany 13, 1905

Wright & Wright

IN THE UNITED STATES PATENT OFFICE.

Application of

Room #382.

Wright and Wright,

10 cls

Flying Machines,

Filed March 23, 1903,

Ser. No. 149,220.

Hon. Commissionerof Patents,

Sir:-

Amendment is hereby made as follows:

Cancelled per Sub Spec Aug 17/05 B

Cancel the claims,and substitute the following:

"(1) In a flying machine, the combination,with two normally parallel aeroplanes superposed the one above the other, of upright standards connecting said planes at their margins, the connections between the standards and aeroplanes at the lateral extremities of the aeroplanes being by means of flexible joints, and means for simultaneously moving the lateral portions of said aeroplanes into different angular relations to the normal planes thereof, the standards maintaining the distance between the portions of the aeroplanes which they connect, substantially as described.

(2) In a flying machine, a normally flat aeroplane having lateral marginal portions capable of movement to different angular positions relatively to the normal plane of the aeroplane and to each other, such movement being about an axis in the plane of the aeroplane transverse to the line of flight, andmeans for simultaneously so moving said marginal portions, substantially as described.

(3) In a flying machine, the combination, with parallel superposed aeroplanes, each having lateral marginal portions movable to different angular positions relatively to the normal plane

of the aeroplane and to each other, of uprights connecting said aeroplanes at their edges, the uprights connecting the lateral margins of the aeroplanes being connected with said aeroplanes by flexible joints, and means for simultaneously imparting to the said lateral marginal portions different angular positions relatively to the normal planes of the respective aeroplanes, such movement being about an axis transverse to the line of flight, the standards maintaining the distance between the parts which they connect, whereby the lateral portions on the same side of the machine are moved to the same angle, substantially as described.

(4) In a flying machine, an aeroplane having substantially the form of a normally flat rectangle elongated transversely to the line of flight, in combination with means for imparting to the lateral margins of said aeroplane a movement about an axis perpendicular thereto and for moving them into different angular relations to the normal plane thereof, substantially as described.

(5) In a flying machine, the combination, with two superposed and normally parallel aeroplanes, each having substantially the form of a normally flat rectangle elongated transversely to the line of flight, of upright standards connecting the edges of said aeroplanes to maintain their equidistance, those standards at the lateral margins of said aeroplanes being connected therewith by flexible joints, and means for simultaneously imparting to the lateral margins of said aeroplanes a movement about an axis perpendicular thereto and for moving them into different angular relations to the normal planes thereof, substantially as described.

(6) In a flying machine, the combination, with an aeroplane, and means for simultaneously moving the lateral portions thereof into different angular relations to the normal plane of the aeroplane and to each other, of a vertical rudder, and means

whereby said rudder is caused to present to the wind that side thereof nearest the end of the aeroplane having the smaller angle of incidence and offering the least resistance to the atmosphere, substantially as described.

(7) In a flying machine, the combination, with an aeroplane, of a normally flat and horizontal flexible rudder, and means for curving said rudder rearwardly and upwardly or rearwardly and downwardly with respect to its normal plane, substantially as described.

(8) A flying machine comprising superposed aeroplanes, means for moving the opposite lateral terminal portions of said aeroplanes to different angles to the normal planes thereof, a vertical rudder, means for moving said vertical rudder toward that lateral terminal portion of the aeroplanes presenting the smallest angle of incidence and the least resistance to the atmosphere, and a flexible horizontal rudder provided with means for curving it upward and rearward or downward and rearward from its normal plane, substantially as described.

(9) In a flying machine, an aeroplane normally flat and elongated transversely to the line of flight, in combination with means for imparting to said aeroplane a helicoidal warp around an axis transverse to the line of flight and extending centrally in the direction of the elongation of the aeroplane, substantially as described.

(10) In a flying machine, two aeroplanes, each normally flat and elongatedtransversely to the line of flight, and upright standards connecting the edges of said aeroplanes to maintain their equidistance, the connections between said standards and aeroplanes being by means of flexible joints, in combination with means for simultaneously imparting to each of said aeroplanes a

~~helicoidal warp around an axis transverse to the line of flight and extending centrally in the direction of the elongation of the aeroplane, substantially as described."~~

N O T E .

Claim 1 hasbeen so amended as to include means for shifting the planes, thus clearly distinguishing it from the rigid frame work of the British patent to Moy. Claim 2 has also been amended to distinguish it from the references by pointing out that the lateral margins of the aeroplane are removed to angles not only different with respect to the normal plane of the body of the aeroplane, but also different with respect to each other. As to claim 3, the reference "Richmond" cited against it cannot be identified, since it has not been previously cited, and no identifying data are given. It is thought, however, that the claim as amended clearly distinguishes it from anything in the prior art and is allowable. As to claims 4 and 5, applicants have availed themselves of the courteous suggestion of the examiner, for which they thank him, and these claims are believed to be in condition for allowance. The formal objections to claims 6, 7 and 8 have also been removed. As to the phrase "smaller angle of incidence", the matter is fully explained in lines 5 to 24 of page 6 of the specification, but, for clearness sake, the difference in resistance to the atmosphere has been introduced into the claims using this phrase, to prevent misunderstanding.

As to present claims 9 and 10, applicants have advised their attorney that they have furnished the examiner with a small cardboard exhibit of which the attorney has a duplicate. This exhibit, in its normal condition, constitutes a tube, rectangular in cross section, of which the opposite sides are parallel. The two vertical sides represent the connecting standards, while the two horizontal sides represent the aeroplanes. If the Examiner will take this exhibit, hold one end in one hand, and the other end in the other hand, in such a position as to have the longitudinal axis of the tube directed away from him, and will then press downward on the right hand upper corner nearest him with the forefinger of his right hand, pressing upward on the lower left hand corner nearest him with the thumb of the same hand, at the same time pressing downward on the upper left hand corner farthest from him with the forefinger of the left hand, and upward on the lower right hand corner farthest from him with the thumb of the left hand, he will then produce upon the upper and lower planes of the structure the same effect which is produced upon the upper and lower planes of the machine by the movement of the cradle J from its central position, and the consequent movement of the parts of the machine explained in the second paragraph beginning on page 4 of the argument accompanying the last amendment. At the same time, if the examiner will glance along the tube while thus distorted, he will see that each surface thereof at the top and bottom is given a helicoidal warp or twist around an axis which is the longitudinal central line of said surface. This must be so in the particular structure embodying two aeroplanes connected by standards of equal length, since the corresponding portion of one of the planes must always be equidistant from the corresponding portion of the other plane, and if the lateral margins of either plane be moved to different angles with respect to each other, the surface of the plane between said lateral margins must have this twist extending uniformly between the two lateral margins. A section taken vertically through one of the planes from front to rear a short distance inward from either edge will show a somewhat less angle to the normal plane, and similar successive sections taken furtherinward will show a constantly decreasing angle, until, it the two margins are moved to equal angles, on opposite sides of the normal plane, a central vertical section from front to rear will show this portion of the plane to be normal. Continuing on toward the other side, a gradually increasing angle in the opposite direction will be found, until the maximum angle will be reached at the further end of the plane. We think that this explanation will make clear the basis of claims 9 and 10, herewith submitted, to which nothing similar is found in the references.

Respectfully submitted,

H. A. Toulmin.
Attorney for applicants. 37

Springfield, Ohio,
January 10, 1905.

C--260.

Div. 23 Room 382. Letter, Paper No. 8.
All communications should be addressed to "The Commissioner of Patents, Washington, D. C." M.
All communications respecting this application should give the serial number, date of filing, and title of invention.

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., May 9, 1905.

Wright & Wright, MAILED " " "

C/o Harry A. Toulmin,

Springfield,
Ohio.

Please find below a communication from the ***EXAMINER*** *in charge of your application,*
Flying Machine, filed March 23, 1903, Serial #149,220.

F. I. Allen

Commissioner of Patents.

On reconsideration of this case with the substitute claims in view, it is found that the ambiguities, inaccuracies, and imperfections of the specification, drawing and claims, (some of which have already been noted) are such as to preclude intelligent action upon the merits of the claims until the defects in question have been remedied.

The chief difficulties arise from the expression "moving the lateral portions of said aeroplanesinto different angular relation to the normal planes thereof", and the like; the term "twist"; the ambiguous use of the terms "lateral", "longitudinal", and "end". Assuming the two wing surfaces in figure 1 to be horizontal andparallel to each other with the two front edges in one vertical plane and the two rear edges in another, it is not clear whether the movement referred to in the first quoted expression is one of the whole of both wing surfaces horizontally and remaining flat about a central vertical axis, or such movement of one surface with reference to the other, or the bending of one corner out of the horizontal plane in one direction and another corner in another direction or of two corners in the same direction but to different extents. The language in question is equally consistent with any of these alternatives as well as with a number of others; apparently, it cannot mean that one end of a wing surface (lateral extension with reference to the longitudinal axis of the device)is distorted with reference to the other end while still remaining flat, since the framing would apparently have to be sufficiently rigid to prevent this. Neither specification nor drawings contain anything definite by which to interpret the expression noted. Lines 9 -10, page 2, refer to the "wing surface or <u>parts thereof</u>" as being "twisted <u>or bent</u> out of their normal planes", making these lines triply ambiguous; line 2, page 3, speaks of imparting a "twist to the entire structure",- an expression not at all understood.

The last 11 lines of page 2, and the first 8 lines of page 4, are not understood at all. "End of the machine", appears to be an error, since the wings extend across the machine and not longitudinally thereof. It is not seen how one edge, either "rear" or "front" could be drawn up when the other is drawn down nor why one should be drawn to a greater extent or angle than the other, nor why the "left set" of wing tips should present a greater or less angle than the right.

Line 14, page 2, should apparently read "The rope F is attached near one rear corner" etc. In line 17, "the" before "front" should be "one". It is not clear how the cradle J provides a means of imparting movement to rope H.

In line 4, page 3, "operating system", should be "device as operated". In line 13, page 3, the terms "lateral" and "longitudinal" are confusingly used.

In line 12, page 4, "relieves" should be "relieve" and it is not clear what is meant by "jerk on the rope H".

In line 2, page 6, "escapes" should be "escape"; in line 8, it is not clear what is meant by "smaller angle of incidence", nor in lines 9 and 11 by "greater angle" , since apparently movement of cradle J would turn or bend the wings to the same extent, if at all.

The illustration is insufficient being in effect a mere diagram and parts being shown on too small a scale. There should be views on a sufficient ~~large~~ scale to clearly show the pulleys and flexing joints as such and also the position of the wing surfaces when moved into "different angular relations".

Most of the difficulties with the new claims are thought to be sufficiently indicated above. It is noted also, as to claim 1, that the term "aeroplane" does not appear in the specification; that it is not clear whether "simultaneously" refers to "lateral portions", or to "aeroplanes", nor how, if the standards flex the aeroplanes can remain the same distance apart. The new claims are in general couched in terms so different from those of the specification as to render interruption difficult.

The "model" filed by applicants has been lost or mislaid and was too crude at best to make their meaning clear. It is suggested that another be furnished more complete in character.

The difficulties noted being of such a character as to preclude intelligent action on the merits, revision of the description and drawings is required before any definite expression of opinion as to novelty. The case, however, appears to disclose patentable subject matter.

The data of the Richmond patent cited in the last action should have been as follows;-

Richmond, #695,580, March 18, 1902;
(Aerial Navigation.

W.W.T. W. W. Townsend
Ex

MAIL ROOM AUG 17 1905 U. S. PATENT OFFICE. U. S. Patent Office, AUG 18 1905 Division XXVIII. Serial No. 149220 Paper No. 9 Sub. Spec Filed Augt. 17, 1905

Wright & Wright

18 cls

IN THE UNITED STATES PATENT OFFICE.

Application of

Wright & Wright,

Flying Machines,

Filed March 23, 1903,

Ser. No. 149,220.

In room #382.

Hon. Commissioner of Patents,

Sir:-

Amendment is hereby made as follows:-

Cancel the present sheet of drawings and substitute therefor the three sheets filed herewith.

Cancel the entire specification, excepting the signatures, and substitute therefor the following new specification.

To all whom it may concern:-

Be it known that we, Orville Wright and Wilbur Wright, ~~both~~ citizens of the United States, residing in the City of Dayton, County of Montgomery and State of Ohio, have invented certain new and useful improvements in Flying Machines, of which the following is a specification.

Our invention relates to that class of flying machines in which the weight is sustained by the reactions resulting when one or more aeroplanes are moved through the air edgewise at a small angle of incidence, either by the application of mechanical power, or by the utilization of the force of gravity. ~~the machine being capable of use either as a soaring machine or as an air ship propelled by a suitable motive power.~~ The objects of our invention are to provide means for maintaining or restoring the equilibrium or lateral balance of the apparatus; to provide means for guiding the machine both vertically and horizontally; and to provide a structure combining lightness, strength, convenience of construction, and certain other advantages which will hereinafter appear. To these ends our invention consists in certain novel features which we will now proceed to describe and will then particularly point out in the claims.

Cancelled
Apr 13/06

In the accompanying drawings, Fig. 1 is a perspective view of an apparatus embodying our invention in one form; Fig. 2 is a plan view of the same, partly in horizontal section and partly broken away; Fig. 3 is a side elevation; and Figs. 4 and 5 are detail views of one form of flexible joint for connecting the upright standards with the aeroplanes.

In flying machines of the character to which this invention relates, the apparatus is supported in the air by reason of the contact between the air and the under surface of one or more aeroplanes, the contact surface being presented at a small angle of incidence to the air. The relative movements of the air and aeroplane may be derived from the motion of the air, in the form of wind blowing in the direction opposite to that in which the apparatus is travelling, or by a combined downward and forward movement of the machine, as in starting from an elevated position, or by combination of these two things, and in either case the operation is that of a soaring machine, while power applied to the machine to propel it positively forward will cause the air to support the machine in a similar manner. In either case, owing to the ~~xxxxxxxx~~ varying conditions to be met, there are numerous disturbing forces which tend to shift the machine from the position which it should occupy to obtain the desired results. It is the chief object of our invention to provide means for remedying this difficulty, and we will now proceed to describe the construction by means of which these results are accomplished.

In the accompanying drawings, we have shown an apparatus embodying our invention in one form. In this illustrative embodiment, the machine is shown as comprising two parallel superposed aeroplanes, 1 and 2, and this construction we prefer, although our invention may be embodied in a structure having a single aeroplane. Each aeroplane is of considerably greater width from side to side than from front to rear. The four corners of the upper aeroplane are indicated by the references letters a, b, c and d, while the corresponding corners of the lower aeroplane 2 are indicated by the reference letters e, f, g and h. The marginal lines a-b and e-f indicate the front edges of the aeroplanes, the lateral margins of the upper aeroplane are indicated respectively by the lines a-d and b-c, the lateral margins of the lower aeroplane are indicated respectively by the lines e-h and f-g, while the rear margins of the upper and lower aeroplanes are indicated respectively by the lines c-d and g-h.

Before proceeding to a description of the fundamental theory of operation of the structure, we will first describe the preferred mode of constructing the aeroplanes and those portions of the structure which serve to connect the two aeroplanes. Each aeroplane is formed by stretching cloth or other suitable fabric over a frame composed of two parallel transverse spars 3, extending from side to side of the machine, their ends being connected by bows 4, extending from front to rear of the machine. The front and rear spars 3 of each aeroplane are connected by a series of parallel ribs 5, which preferably extend somewhat beyond the rear spar, as shown. These spars, bows and ribs are preferably constructed of wood having the necessary strength, combined with lightness and flexibility. Upon this frame work the cloth which forms the supporting surface of the aeroplane is secured, the frame being enclosed in the cloth. The cloth for each aeroplane, previously to its attachment to its frame, is cut on the bias and made up into a single piece approximately the size and shape of the aeroplane, having the threads of the fabric arranged diagonally to the transverse spars and longitudinal ribs, as indicated at 6 in Fig. 2. Thus the diagonal threads of the cloth form truss systems with the spars and ribs, the threads constituting the diagonal members. A hem is formed at the rear edge of the cloth to receive a wire 7, which is connected to the ends of the rear spar and supported by the rearwardly extending ends of the longitudinal ribs 5, thus forming a rearwardly extending flap or portion of the aeroplane. This construction of the aeroplanes gives a surface which has very great strength to withstand lateral and longitudinal strains, at the same time being capable of being bent or twisted in the manner hereinafter described.

When two aeroplanes are employed, as in the construction illustrated, they are connected together by upright standards 8. These standards are substantially rigid, being preferably constructed of wood, and of equal length, equally spaced along the front and rear edges of the aeroplane, to which they are connected at their top and bottom ends by hinged joints or universal joints of any suitable description, We have shown one form of connection which may be used for this purpose in Figs. 4 and 5 of the drawings. In this construction, each end of the standard 8 has secured to it an eye 9, which engages with a hook 10, secured to a bracket plate 11, which latter plate is in turn fastened to the spar 3. Diagonal braces or stay wires 12 extend from each end of each standard to the opposite ends of the adjacent standards, and as a convenient mode of attaching these parts I have shown a hook 13, made integral with the hook 10, to receive the end of one of the stay wires, the other stay wire being mounted on the hook 10. The hook 13 is shown as bent down to retain the stay wire in connection to it, while the hook 10 is shown as provided with a pin 14 to hold the stay wire 12 and eye 9 in position thereon. It will be seen that this construction forms a truss system which gives the whole machine great transverse rigidity and strength, while at the same time the jointed connections of the parts permit the aeroplanes to be bent or twisted in the manner which we will now proceed to describe.

15 indicates a rope or other flexible connection, extending lengthwise of the front of the machine above the lower aeroplane, passing under pulleys or other suitable guides 16 at the front corners e and f of the lower aeroplane, and extending thence upward and rearward to the upper rear corners c and d of the upper aeroplane, where they are attached, as indicated at 17. To the central portion of this rope there is connected a laterally movable cradle 18, which forms a means for moving the rope lengthwise in one direction or the other, the cradle being movable toward either side of

the machine. We have devised this cradle as a convenient means for operating the rope 15, and the machine is intended to be generally used with the operator lying face downward on the lower aeroplane, with his head to the front, so that the operator's body rests on the cradle, and the cradle can be moved laterally by the movements of the operator's body. It will be understood, however, that the rope 15 may be manipulated in any suitable manner. 19 indicates a second rope extending transversely of the machine along the rear edge of the body portion of the lower aeroplane, passing under suitable pulleys or guides 20 at the rear corners g and h of the lower aeroplane, and extending thence diagonally upward to the front corners a and b of the upper aeroplane, where its ends are secured in any suitable manner, as indicated at 21.

Considering the structure so far as we have now described it, and assuming that the cradle 18 be moved to the right in Figs. 1 and 2, as indicated by the arrows applied to the cradle in Fig. 1 and by the dotted lines in Fig. 2, it will be seen that that portion of the rope 15 passing under the guide pulley at the corner e and secured to the corner d will be under tension, while slack is paid out throughout the other side or half of the rope 15. The part of the rope 15 under tension exercises a downward pull upon the rear upper corner d of the structure and an upward pull upon the front lower corner e, as indicated by the arrows. This causes the corner d to move downward and the corner e to move upward. As the corner e moves upward it carries the corner a upward with it, since the intermediate standard 8 is substantially rigid and maintains an equal distance between the corners

a and e at all times. Similarly, the standard 8 connecting the corners d and h causes the corners h to move downward in unison with the corner d. Since the corner a thus moves upward and the corner h moves downward, that portion of the rope 19 connected to the corner a will be pulled upward through the pulley 20 at the corner h, and the pull thus exerted on the rope 19 will pull the corner b on the other side of the machine downward and at the same time pull the corner g at said other side of the machine upward. This results in a downward movement of the corner b and an upward movement of the corner c. Thus it results from a lateral movement of
Dec 6/05 the cradle 18 to the right in Fig. ~~2~~ 1 that the lateral margins a-d and e-h at one side of the machine are moved from their normal positions, in which they lie in the normal planes of their respective aeroplanes, into angular relations with said normal planes, each lateral margin on this side of the
Dec 6/05 machine being ~~depressed below~~ raised above said normal plane at its forward end and ~~raised above~~ depressed below said normal plane at its rear end,
" " " said lateral margins being ~~thus~~ thus inclined ~~downward~~ upward and forward. At the same time, a reverse inclination is imparted to the lateral margins b-c and f-g at the other side of the
Dec 6/05 machine, their inclination being ~~upward~~ downward and forward. These positions are indicated in dotted lines in Fig. 1 of the drawings. A movement of the cradle 18 in the opposite direction from its normal position will reverse the angular inclination of the lateral margins of the aeroplanes in an obvious manner. By reason of this construction it will be seen that, with the particular mode of construction now under consideration, it is possible to move the forward corner of

the lateral edges of the aeroplane on one side of the machine either above or below the normal planes of the aeroplanes, a reverse movement of the forward corners of the lateral margins on the other side of the machine occurring simultaneously. During this operation, each aeroplane is twisted or distorted around a line extending centrally across the same from the middle of one lateral margin to the middle of the other lateral margin, the twist due to the moving of the lateral margins to different angles extending across each aeroplane from side to side, so that each aeroplane surface is given a helicoidal warp or twist. We prefer this construction and mode of operation, for the reason that it gives a gradually increasing angle to the body of each aeroplane from the central longitudinal line thereof outward to the margin, thus giving a continuous surface on each side of the machine which has a gradually increasing or decreasing angle of incidence from the center of the machine to either side. We wish it to be understood, however, that our invention is not limited to this particular construction, since any construction whereby the angular relations of the lateral margins of the aeroplanes may be varied in opposite directions with respect to the normal planes of said aeroplanes comes within the scope of our invention. ~~For instance, it is not necessary that the entire body of the aeroplane should be distorted in the manner described, since separate sections of the aeroplanes at the sides thereof may be made movable relatively to the main bodies or normal planes of the aeroplanes, and the transverse axes around which these movements~~

Cancelled
Dec 6/05

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occur may be located either at the front or rear of the machine, or at any suitable intermediate point. Furthermore, it should be understood that while the lateral margins of the aeroplanes move to different angular positions with respect to or above and below the normal planes of said aeroplanes, it does not necessarily follow that these movements bring the opposite lateral edges to different angles respectively above and below a horizontal plane, since the normal planes of the bodies of the aeroplanes are inclined to the horizontal when the machine is in flight, said inclination being downward from front to rear, and while the forward corners on one side of the machine may be depressed below the normal planes of the bodies of the aeroplanes, said depression is not necessarily sufficient to carry them below the horizontal planes passing through the rear corners on that side. Moreover, although we prefer to so construct the apparatus that the movements of the lateral margins on the opposite sides of the machine are equal in extent and opposite in direction, yet our invention is not limited to a construction producing this result, since it may be desirable, under certain circumstances, to move the lateral margins on one side of the machine in the manner just described without moving the lateral margins on the other side of the machine to an equal extent in the opposite direction.

Turning now to the purpose of this provision for moving the lateral margins of the aeroplanes in the manner described, it should be premised that, owing to various conditions of wind pressure and other causes, the body of the machine is apt to become unbalanced laterally, one side tending to sink and the other side tending to rise, the machine turning around its central longitudinal axis. The provision which we have just described enables the operator to meet this difficulty and preserve the lateral balance of the machine. Assuming that for some cause that side of the machine which lies to the left of the observer in Figs. 1 and 2 has shown a tendency to drop downward, a movement of the cradle 18 to the right of said Figures, as hereinbefore assumed, will move the lateral margins of the aeroplanes in the manner already described, so that the margins a-d and e-h will be inclined downward and rearward and the lateral margins b-c and f-g will be inclined upward and rearward with respect to the normal planes of the bodies of the aeroplanes. With the parts of the machine in this position, it will be seen that the lateral margins a-d and e-h present a larger angle of incidence to the resisting air, while the lateral margins on the other side of the machine present a smaller angle of incidence. Owing to this fact, the side of the machine presenting the larger angle of incidence will tend to lift or move upward, and this upward movement will restore the lateral balance of the machine. When the other side of the machine tends to drop, a movement of the cradle 18 in the reverse direction will restore the machine to its normal lateral equilibrium. Of course, the same effect will be produced in the same way in the case of a machine employing only a single aeroplane.

In connection with the body of the machine as thus operated, we employ a vertical rudder or tail 22, so supported as to turn around a vertical axis. This rudder is supported at the rear ends of supports or arms 23, pivoted at their forward ends to the rear margins of the upper and lower aeroplanes respectively. These supports are preferably V-shaped, as shown, so that their forward ends are comparatively widely separated, their pivots being indicated at 24. Said supports are free to swing upward at their free rear ends, as indicated in dotted lines in Fig. 3, their downward movement being limited in any suitable manner. The vertical pivots of the rudder 22 are indicated at 25, and one of these pivots has mounted thereon a sheave or pulley 26, around which passes a tiller rope 27, the ends of which are extended out laterally and secured to the rope 19 on opposite sides of the central point of said rope. By reason of this construction, the lateral shifting of the cradle 18 serves to turn the rudder to one side or the other of the line of flight. It will be observed, in this connection, that the construction is such that the rudder will always be so turned as to present its resisting surface on that side of the machine on which the lateral margins of the aeroplanes present the least angle of resistance. The reason of this construction is that when the lateral margins of the aeroplanes are so turned, in the manner hereinbefore described, as to present different angles of incidence to the atmosphere, that side presenting the largest angle of incidence, although being lifted or moved upward in the manner already described, at the same time meets with an increased resistance to its forward motion, and is therefore retarded in its forward motion, while at the same time the other side of the machine, presenting a smaller angle of incidence, meets with less resistance to its forward motion. and tends to move forward more rapidly than the retarded side. This gives the machine a tendency to turn around its vertical axis, and this tendency, if not properly met, will not only change the direction of the front of the machine, but will ultimately permit oneside thereof to drop into a position vertically below the other side, with the aeroplanes in vertical position, thus causing the machine to fall. The movement of the rudder hereinbefore described prevents this action, since it exerts a retarding influence on that side of the machine which tends to move forward too rapidly, and keeps the machine with its front properly presented to the direction of flight and with its body properly balanced around its central longitudinal axis. The pivoting of the supports 23 so as to permit them to swing upward prevents injury to the rudder and its supports in case the machine alights at such an angle as to cause the rudder to strike the ground first, the parts yielding upward, as indicated in dotted lines in Fig. 3, and thus preventing injury or breakage. We wish it to be understood, however, that we do not limit ourselves to the particular description of rudder set forth, the essential being that the rudder shall be vertical, and shall be so moved as to present its resisting surface on that side of the machine which offers the least resistance to the atmosphere, so as to counteract the tendency of the machine to turn around a vertical axis when the two sides thereof offer different resistances to the air.

From the central portion of the front of the machine struts 28 extend horizontally forward from the lower aeroplane, and struts 29 extend downward and forward from the central portion of the upper aeroplane, their front ends being united to the struts 28, the forward extremities of which are turned up, as indicated at 30. These struts 28 and 29 form truss skids projecting in front of the whole frame of the machine and serving to prevent the machine from rolling over forward when it alights. The struts 29 serve to brace the upper portion of the main frame and resist its tendency to move forward after the lower aeroplane has been stopped by its contact with the earth, thereby relieving the rope 19 from undue strain. For it will be understood that, when the machine comes into contact with the earth, further forward movement of the lower portion thereof being suddenly arrested, the inertia of the upper portion would tend to cause it to continue to move forward if not prevented by the struts 29, and this forward movement of the upper portion would bring a very violent strain upon the rope 19, since it is fastened to the upper portion at both of its ends, while its lower portion is connected by the guides 20 to the lower portion.

The struts 28 and 29 also serve to support the front or horizontal rudder, the construction of which we will now proceed to describe. The front rudder 31 is a horizontal rudder having a flexible body, the same consisting of three stiff cross pieces or sticks 32, 33 and 34, and the flexible ribs 35, connecting said cross pieces and extending from front to rear. The frame thus provided is covered by a suitable fabric stretched over the same to form the body of the rudder. The rudder is supported from the struts 29 by means of the intermediate cross piece 32, which is located near the center of pressure, slightly in front of a line equidistant between the front and rear edges of the rudder, the cross piece 32 forming the pivotal axis of the rudder, so as to constitute abalanced rudder. To the front edge of the rudder there are connected springs 36, which springs are connected to the upturned ends 30 of the struts 28, the construction being such that said springs tend to resist any movement either upward or downward of the front edge of the horizontal rudder. The rear edge of the rudder lies immediately in front of the operator, and may be operated by him in any suitable manner. We have shown a mechanism for this purpose, comprising a roller or shaft 37, which may be grasped by the operator so as to turn the same in either direction. Bands 38 extend from the roller 37 forward to and around a similar roller or shaft 39, both rollers or shafts being supported in suitable bearings on thestruts 28. The forward roller or shaft has a rearwardly extending arms 4o, which are connected bylinks 41 with the rear edge of the rudder 31. The normal position of the rudder 31 is neutral, or substantially parallel with the aeroplanes 1 and 2, but its rear edge may be moved upward or downward, so as to be above or below the normal plane of said rudder, through the mechanism provided for that purpose. It will be seen that the springs

36 will resist any tendency of the forward edge of the rudder to move in either direction, so that when force is applied to the rear edge of said rudder, the longitudinal ribs 35 bend, and the rudder thus presents a concave surface to the action of the wind, either above or below its normal plane, said surface presenting a small angle of incidence at its forward portion, and said angle of incidence rapidly increasing towards the rear. This greatly increasesthe efficiency of the rudder as compared with a plane surface of equal area. By regulating the pressure on the upper and lower sides of the rudder through changes of angle and curvature in the manner described, a turning movement of the main structure around its transverse axis may be effected, and the course of the machine may thus be directed upward or downward, at the will of the operator, and the longitudinal balance thereof maintained.

Contrary to the usual custom, we place the horizontal rudder in front of the aeroplanes at a negative angle, and employ no horizontal tail at all. By this arrangement we obtain a forward surface which is almost entirely free from pressure under ordinary conditions of flight, but which, even if not moved at all from its original position, becomes an efficient lifting surface whenever the speed of the machine

Dec 6/05 is accidentally ~~correspondingly~~ reduced very much below the normal, and thus largely counteracts that backward travel of the center of pressure on the aeroplanes which has frequently been productive of serious injuries by causing the machine to turn downward and forward and strike the ground head-on. We are aware that a forward horizontal rudder of different construction has been used in combination with a supporting surface and a rear horizontal rudder, but this combination was not intended to effect and does not effect the object which we obtain by the arrangement hereinbefore described.

We have used the term aeroplane in this specification and the appended claims to indicate the supporting surface or supporting surfaces by means of which the machine is sustained in the air, and by thisterm we wish to be understood as including any suitable supporting surface which normally is substantially flat, although, of course, when constructed of cloth or other flexible fabric, as we prefer to construct them, these surfaces may receive more or less curvature from the resistance of the air, as indicated in Fig. 3.

We do not wish to be understood as limiting ourselves strictly to the precise details of construction hereinbefore described and shown in the accompanying drawings, as it is obvious that these details may be modified without departing from the principlesof our invention. For instance, while we prefer the construction illustrated, in which each aeroplane is given a twist along its entire length in order to set its opposite lateral margins at different angles, we have already pointed out that our invention is not limited to this form of construction, since it is only necessary to move the lateral marginal portions, and where these portions alone aremoved, only those upright standards which support the movable portion require flexible connections at their ends.

Having thus fully described our invention, what we claim as new and desire to secure by letters patent is:-

(1) In a flying machine, a normally flat aeroplane having lateral marginal portions capable of movement to different positions above or below the normal plane of the body of the aeroplane, such movement being about an axis transverse to the line of flight, whereby said lateral marginal portions may be moved to different angles relatively to the normal plane of the body of the aeroplane, so as to present to the atmosphere different anglesof incidence, and means for so moving said lateral marginal portions, substantially as described.

(2) In a flying machine, the combination, with two normally parallel aeroplanes, superposed the one above the other, of upright standards connecting said planes at their margins, the connections between the standards and aeroplanes at the lateral portions of the aeroplanes being by means of flexible joints, each of said aeroplanes having lateral marginal portions capable of movement to different positions above or below the normal plane of the body of the aeroplane, such movement being about an axis transverse to the line of flight, whereby said lateral marginal portions may be moved to different angles relatively to the normal plane of the body of the aeroplane, so as to present to the atmosphere different angles of incidence, the standards maintaining a fixed distance between the portions of the aeroplanes which they connect, and means for imparting such movement to the lateral marginal portions of the aeroplanes, substantially as described.

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(3) In a flying machine, a normally flat aeroplane having lateral marginal portions capable of movement to different positions above or below the normal plane of the body of the aeroplane, such movement being about an axis transverse to the line of flight, whereby said lateral marginal portionsmay be moved to different angles relatively to the normal plane of the body of the aeroplane, and also to different angles relatively to each other, so as to present to the atmosphere different angles of incidence, and means for simultaneously imparting such movement to said lateral marginal portions, substantially as described.

(4) In a flying machine, the combination, with parallel superposed aeroplanes, each having lateral marginal portions capable of movement to different positions above or below the normal plane of the body of the aeroplane, such movement being about an axis transverse to the line of flight, whereby said lateral marginal portionsmay be moved to different anglesrelatively to the normal plane of the body of the aeroplane, and to different angles relatively to each other, so as to present to the atmosphere different angles of incidence, of uprights connecting said aeroplanes at their edges, the uprights connecting the lateral portions of the aeroplanes being connected with said aeroplanes by flexible joints, and means for simultaneously imparting such movement to said lateralmarginal portions, the standards maintaining a fixed distance between the parts which they connect, whereby the lateral portions on the same side of the machine are moved to the same angle, substantially as described. 59

(5) In a flying machine, an aeroplane having substantially the form of a normally flat rectangle elongated transversely to the line of flight, in combination with means for imparting to the lateral margins of said aeroplane a movement about an axis lying in the body of the aeroplane perpendicular to said lateral margins, and thereby moving said lateral margins into different angular relations to the normal plane of the body of the aeroplane, substantially as described.

(6) In a flying machine, the combination, with two superposed and normally parallel aeroplanes, each having substantially the form of a normally flat rectangle elongated transversely to the line of flight, of upright standards connecting the edges of said aeroplanesto maintain their equidistance, those standards at the lateral portions of said aeroplanesbeing connected therewith by flexible joints, and means for simultaneously imparting to both lateral margins of both aeroplanes a movement about axes which are perpendicular to said margins and in the planes of the bodies of the respective aeroplanes,and ~~fxx~~ thereby moving the lateral margins on the opposite sides of the machine into different angular relations to the normal planesof the respective aeroplanes, the margins on the same side of the machine moving to the same angle, and the margins on one side of the machine moving to an angle different from the angle to which the margins on the other side of the machine move, substantially as described.

(7) In a flying machine, the combination, with an aeroplane, and means for simultaneously moving the lateral

portions thereof into different angular relations to the normal plane of the body of the aeroplane and to each other, so as to present to the atmosphere different angles of incidence, of a vertical rudder, and means whereby said rudder is caused to present to the wind that side thereof nearest the side of the aeroplane having the smaller angle of incidence and offering the least resistance to the atmosphere, substantially as described.

(8) In a flying machine, the combination, with two superposed and normally parallel aeroplanes, upright standards connecting the edges of said aeroplanesto maintain their equidistance, those standards at the lateral portions of said aeroplanes being connected therewith by flexible joints, and means for simultaneously moving both lateral

Dec 6/05 portions of both aeroplanesinto different angular relations to the normal planes of the bodies of the respective aeroplanes, the lateral portions on one side of the machine being moved to an angle different from that to which the lateral portions on the other side of the machine are moved, so as to present different angles of incidence at the two sides of the machine, of a vertical rudder, and means whereby said rudder is caused to present to the wind that side thereof nearest the side of the aeroplaneshaving the smaller angle of incidence and offering the least resistance to the atmosphere, substantially as described.

(9) In a flying machine, an aeroplane normally flat and elongated transversely to the line of flight, in

Dec 6/05 combination with means for imparting to said aeroplane a helicoidal warp around an axis transverse to the line of flight and extending centrally along the body of the aeroplane in the direction of the elongation of the aeroplane, substantially as described.

(10) In a flying machine, two aeroplanes, each normally flat and elongated transversely to the line of flight, and upright standards connecting the edges of said aeroplanes to maintain their equidistance, the connections between said standards and aeroplanes being by means of flexible joints, in combination with means for simultaneously imparting to each of said aeroplanes a helicoidal warp around an axis transverse to the line of flight and extending centrally along the body of the aeroplane in the direction of the elongation of the aeroplane, substantially as described.

(11) In a flying machine, two aeroplanes, each normally flat and elongated transversely to the line of flight, and upright standards connecting the edges of said aeroplanes to maintain their equidistance, the connections between said standards and aeroplanes being by means of flexible joints, in combination with means for simultaneously imparting to each of said aeroplanes a helicoidal warp around an axis transverse to the line of flight and extending centrally along the body of the aeroplane in the direction of the elongation of the aeroplane, a vertical rudder, and means whereby said rudder is caused to present to the wind that side thereof nearest the side of the aeroplanes having the smaller angle of incidence and offering the least resistance to the atmosphere, substantially as described.

(12) In a flying machine, the combination, with an aeroplane, of a normally flat and substantially horizontal flexible rudder, and means for curving said rudder rearwardly and upwardly or rearwardly and downwardly with respect to its normal plane, substantially as described.

(13) In a flying machine, the combination, with an aeroplane, of a normally flat and substantially horizontal flexible rudder pivotally mounted on an axis transverse to the line of flight near its center, springs resisting vertical movement of the front edge of said rudder, and means for moving the rearedge of said rudder above or below the normal plane thereof, substantially as described.

(14) A flying machine comprising superposed connected aeroplanes, means for moving the opposite lateral portions of said aeroplanes to different angles to the normal planes thereof, a vertical rudder, means for moving said vertical rudder toward that side of the machine presenting the smaller angle of incidence and the least resistance to the atmosphere, and a horizontal rudder provided with means for presenting its upper or under surface to the resistance of the atmosphere, substantially as described.

(15) A flying machine comprising superposed connected aeroplanes, means for moving the opposite lateral portion of said aeroplanes to different angles to the normal planes thereof, a vertical rudder, means for moving said vertical rudder toward that side of the machine presenting the smaller angle of incidence and the least resistance to the atmosphere, and a horizontal rudder provided with means for presenting its upper or under surface to the resistance of

the atmosphere, said vertical rudder being located at the rear of the machine and said horizontal rudder at the front of the machine, substantially as described.

(16) In a flying machine, the combination, with two superposed and connected aeroplanes, of an arm extending rearward from each aeroplane, said arms being parallel and free to swing upward at their rear ends, and a vertical rud-

Dec 6/05 der pivotally mounted in the rear ends of said arms, substantially as described.

(17) A flying machine comprising two superposed aeroplanes, normally flat but flexible, upright standards connecting the margins of said aeroplanes, said standards being connected to said aeroplanesby universal joints, diagonal stay wires connecting the opposite ends of the adjacent standards, a rope extending along the front edge of the lower aeroplane, passing through guides at the front corners thereof, andhaving its ends secured to the rear corners of the upper aeroplane, and a rope extending along the rear edge of the lower aeroplane, passing through guides at the rear corners thereof, and having its ends secured to the front corners of the upper aeroplanes, substantially as described.

(18) A flying machine comprising two superposed aeroplanes, normally flat but flexible, upright standards connecting the margins of said aeroplanes, said standards being connected to said aeroplanes by universal joints, diagonal stay wires connecting the opposite ends of the adjacent standards, a rope extending along the front edge of the lower aeroplane, passing through guides at the front corners thereof, and having its ends secured to the rear corners of the

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upper aeroplane, and a rope extending along the rear edge of the lower aeroplane, passing through guides at the rear corners thereof, and having its ends secured to the front corners of the upper aeroplane, in combination with a vertical rudder, and a tiller rope connecting said rudder with the rope extending along the rear edge of the lower aeroplane, substantially as described.

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NOTE.

The foregoing amended specification is submitted in accordance with the request of the examiner, the promise made by applicants' attorney to furnish a revised specification, and the personal interview between applicants' attorney and the examiner, at which time a model exhibit of the invention was submitted and explained to the examiner, and the descriptive terms to be employed were agreed upon. The language of the specification and claims is now the same, the claims being substantially the same as those last submitted, with such modifications of language as were deemed necessary to make them clear, and with the addition of one or two claims further developing the same subject matter which was agreed upon as patentable. We also furnish herewith a new set of drawings, made in accordance with the requirements of the examiner and chief draftsman, which drawings we believe fully and clearly illustrate the invention, so that the same may be readily understood in connection with the new specification. An allowance of the application as now submitted is respectfully requested.

Respectfully submitted,

H. A. Toulmin.
Attorney for applicants.

Springfield, Ohio,
Aug. 15, 1905.

2-260.

Div. 28 Room 382
All communications should be addressed to "The Commissioner of Patents, Washington, D. C."

Paper No. 10 Rej.
All communications respecting this application should give the serial number, date of filing, and title of invention.

M.E.M.

DEPARTMENT OF THE INTERIOR,

H.R.B.

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., December 2, 1905.

O. & W. Wright

H. A. Toulmin,

Springfield, Ohio.

Please find below a communication from the **EXAMINER** *in charge of your application,* for Flying Machines; filed March 23, 1903; Serial Number 149,220.

F. I. Allen

Commissioner of Patents.

This case, as amended August 17, 1905, has been considered.

Beginning at the comma in line 12, page 2, the matter to the end of the sentence lacks foundation and furthermore it is new matter. There is nothing in the case as filed upon which to base the statement and there is not, even at present, any description or illustration of the modifications that would be required for an airship. The letter a is not found on the drawing.

In lines 19 to 24, inclusive, page 8, the words raised above, depressed below, upward, downward, and forward all express just the reverse of the real inclination.

The modification mentioned in the last sentence on page 9, should be illustrated if the description is retained. It is thought, however, that it constitutes new matter.

It is not clear what is meant by correspondingly in line 5 from the bottom of page 16.

It is thought that the word different has been omitted after "into" in line 7 claim 8. In the last line of page 21 aeroplanes should be aeroplane.

Claim 16 should read " a vertical rudder pivotally mounted etc" or equivalently, to distinguish patentably from the British patent, May #15,221, June 25, 1897.

W. W. Townsend
Examiner Division 28.

MAIL ROOM
DEC 6 1905
U. S. PATENT OFFICE.

U. S. Patent Office,
DEC 7 1905
Division XXVIII.

Serial No. 149220 Paper No. 11
Amendment.
Filed Dec 6, 1905

Wright & Wright

IN THE UNITED STATES PATENT OFFICE.

(18 cls)

Application of Wright and Wright,

Flying Machines,

Filed March 23, 1903,

Room 382

Ser. No. 149,220.

Hon. Commissioner of Patents,

Sir:-

Amendment is hereby made as follows:-

Page 8, line 12, change the numeral "2" to 1.

Same page, line 17, erase the words "depressed below", and substitute the words raised above.

Same page, line 18, erase the words "raised above", and substitute the words depressed below.

Same page, line 19, change "this" to thus and "downward" to upward.

Same page, line 22, change "upward to downward.

Cancel the sentence beginning at line 23 of page 9 and ending at line 2 of page 10.

Page 16, line 24, erase the word "correspondingly", and substitute the word accidentally.

Claim 8, line 7 of claim, after the word "into", insert the word different.

Claim 9, line 3, of claim, strike out the final "s" of the word "aeroplanes."

Claim 16, line 5 of claim, before the word "mounted", insert the word pivotally.

The Office is requested to supply the reference letter "a" in Fig. 1 in accordance with the print filed herewith, on which the correction is indicated in red ink.

NOTE.

With regard to the matter objected to, beginning at line 12 of page 2, it is thought that the examiner has somewhat misunderstood the application of the matter objected to to the invention. The statement in question is merely a statement of fact, and, as such, no objection to it can be seen, It is not an attempt to either describe or illustrate any modification whatever of the structure now illustrated and described, which is identical with the structure originally illustrated and described. The fact is that the structure upon which the application is based, and to which all of the claims relate, may be used either as a soaring machine or as a flying machine. As a matter of fact, it has been successfully used for both purposes. But its particular form of use involves no changes in the character or mode of operation of the structure itself, which is identical with that shown in the drawings, whether it be employed in one way or the other. This was clearly brought out in the specification as originally filed, in which, in lines 10 and 11 of page 1, it was stated that the invention belonged to a class of machines having certain characteristics of structure and operation when moved "either by the application of mechanical power, or by the utilization of the force of gravity." There is thus ample basis for the statement in the case as originally filed. Since the structure features illustrated and upon which the claims are based have exactly the same mode of operation and accomplish exactly the same results, whether the machine is used as a soaring machine, operated by gravity, or as a flying machine, ~~operated~~ by mechanical means, and this fact was stated in the application as originally filed, it cannot be seen how the retention of saidstatement in the specification can be reasonably objected to.

Although the modification referred to on pages 9 and 10 is clearly within the scope of applicants' invention, it has been canceled in view of the necessity of illustrating the same if any specific reference thereto is retained in the specification.

The various corrections indicated have been made, and it is believed that the application is now in condition for allowance, which is respectfully requested.

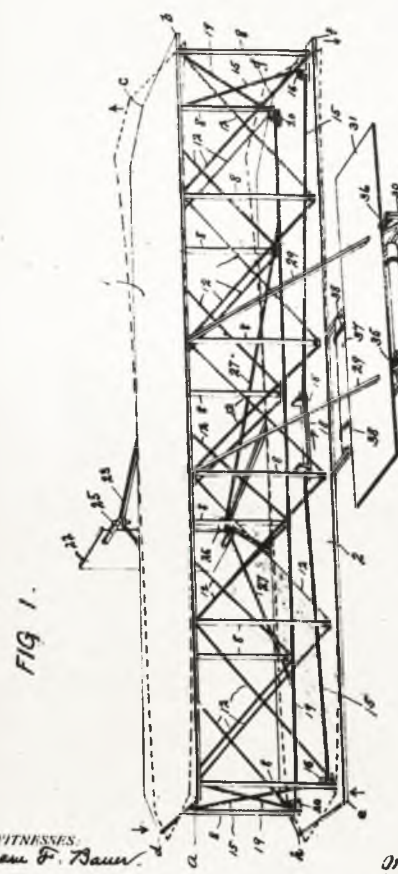
Respectfully submitted,

H. A. Toulmin,
Attorney for applicants.

Springfield, Ohio, Dec. 4, 1905.

Serial No. 149,220 ... Sheets-Sheet

Sub drawing filed Aug. 19, 1905 —



WITNESSES:
William F. Bauer
Irvine Miller

INVENTORS
Orville Wright
Wilbur Wright
BY H. A. Toulmin.
ATTORNEY.

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1912

2—260.

Div. 23. Room....382. M. Letter, Paper No. 12.

All communications should be addressed to "The Commissioner of Patents, Washington, D. C."

All communications respecting this application should give the serial number, date of filing, and title of invention.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Jan. 26, 1906.

Wright & Wright, MAILED " " "

C/o Harry A. Toulmin,

Springfield,
Ohio.

Please find below a communication from the EXAMINER in charge of your application, Flying Machines, filed March 23, 1903, Serial #149,220.

F.I.Allen

Commissioner of Patents.

This case has been considered in connection with the amendment of Dec. 6, 1905.

Lines 10 and 11, page 1, of the original specification, do not necessarily imply anything but what is already illustrated and described and cannot therefore afford a basis for the statement objected to. The phrase "by the application of mechanical power", is broad enough to include various ways of flying the machine - for example, by towing it from an automobile, steam boat, railway car or other vehicle - which would not involve any change whatever in the structure of the device as already shown. These is no ground therefore for objecting to these lines.

The objectionable matter stands on a very different footing. The device cannot act as "an air ship propelled by a suitable motive power" without some sort of propelling means, such as a screw, wings or paddle wheel, and some sort of motor to supply the power. The , are essential elements in an air ship. Hence the lines objected to imply, not merely a different way of using the machine illustrated, but a modification of that machine made by adding elements, (and making other changes if necessary) that transform it into a different type of vessel which has not been described nor shown and whose description and illustration cannot be introduced now as it would constitute new matter.

Hence the requirement of cancellation of the objectionable lines is repeated and made final.

H R B

O. C. Gsantner,
Asst Exr In chge.

U. S. Patent Office,
APR 13 1906
Division XXVIII.

Serial No. 149220 Paper No. 13
Amendment.
Filed Apr. 13, 1906

Wright & Wright
(18 cls)

IN THE UNITED STATES PATENT OFFICE.

Application of
Wright & Wright,
Flying Machines,
Filed March 23, 1903,
Ser. No. 149,220.

Room 332.

Hon. Commissioner of Patents,

Sir:-

Amendment is hereby made as follows:-

Page 1, line 12, change the comma to a period and cancel the matter following the same in said line and in lines 13 and 14, down to and including the period in line 14.

N O T E .

The foregoing amendment removes the only objection now made against this application, and puts the same in condition for allowance, which is respectfully requested.

In making this amendment applicants beg leave to again call attention to the fact that the machine described and claimed in this application has been repeatedly and successfully used as a flying machine in connection with a mechanical motor; that the claims now in the application read upon the structure so organized just as accurately and completely as they do upon thestructure illustrated in the drawings of this case, and that the cancellation of the matter referred to is in no way a concession that the application does not in fact cover such machine, or that the machine of

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the application may not, as heretofore, be used with a mechanical motor. What this machine, so equipped, has accomplished is too well known to those familiar with aeronautics to require discussion here, and the foregoing statement is made solely for the purpose of preventing the present amendment from being so construed as to prejudice any of applicants' rights.

Respectfully submitted,

H. A. Toulmin,

Attorney for applicants. 75

Springfield, Ohio,

March 17, 1906.

1915

IN REMITTING THE FINAL FEE GIVE THE SERIAL NUMBER AT THE HEAD OF THIS NOTICE.

SM

Issue Division.

All communications should be addressed to "The Commissioner of Patents, Washington, D. C."

2-181.

Serial No. 149,220

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., Apr. 21, 1906.

Orville Wright and Wilbur Wright,
C/o Harry A. Toulmin,
Springfield, Ohio.

SIR: Your ***APPLICATION*** *for a patent for an* ***IMPROVEMENT IN***

Flying Machines,

filed Mch. 23, 1903 *, has been examined and* ***ALLOWED.***

The final fee, ***TWENTY DOLLARS,*** *must be paid, and the Letters Patent bear date as of a day not later than* ***SIX MONTHS*** *from the time of this present notice of allowance.*

If the final fee is not paid within that period the patent will be withheld, and your only relief will be by a renewal of the application, with additional fees, under the provisions of Section 4897, Revised Statutes. The office aims to deliver patents upon the day of their date, and on which their term begins to run; but to do this properly applicants will be expected to pay their final fees at least ***TWENTY DAYS*** *prior to the conclusion of the six months allowed them by law. The printing, photolithographing, and engrossing of the several patent parts, preparatory to final signing and sealing, will consume the intervening time, and such work will not be done until after payment of the necessary fees.*

When you send the final fee you will also send, ***DISTINCTLY AND PLAINLY WRITTEN,*** *the name of the* ***INVENTOR*** *and* ***TITLE OF INVENTION AS ABOVE GIVEN, DATE OF ALLOWANCE*** *(which is the date of this circular),* ***DATE OF FILING,*** *and, if assigned, the* ***NAMES OF THE ASSIGNEES.***

If you desire to have the patent issue to ***ASSIGNEES,*** *an assignment containing a* ***REQUEST*** *to that effect, together with the* ***FEE*** *for recording the same, must be filed in this office on or before the date of payment of final fee.*

After issue of the patent uncertified copies of the drawings and specifications may be purchased at the price of ***FIVE CENTS EACH.*** *The money should accompany the order. Postage stamps will not be received.*

Respectfully,

F. I. Allen

Commissioner of Patents.

XX UNCERTIFIED CHECKS WILL NOT BE ACCEPTED XX

After allowance, and prior to payment of the final fee, applicants should carefully scrutinize the description to see that their statements and language are correct, as mistakes not incurred through the fault of the office, and not affording legal grounds for reissues, will not be corrected after the delivery of the letters patent to the patentee or his agent.

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$20 RECEIVED
MAY 3 1906 ck s
CHIEF CLERK,
U. S. PATENT OFFICE.

Springfield, Ohio, May 1, 1906.

Hon. Commissioner of Patents,

Washington, D. C.

Sir:-

Enclosed please find check for twenty dollars, ($20.00), in payment of the final government fee upon the allowed application of Messrs. Orville and Wilbur Wright for improvements in Flying Machines, filed March 23, 1903, Ser. No. 149,220. We also enclose the final fee slip, duly filled out. Please have the patent issue accordingly, and send the same to us when issued.

77 Very respectfully,

H. A. Toulmin,
H.

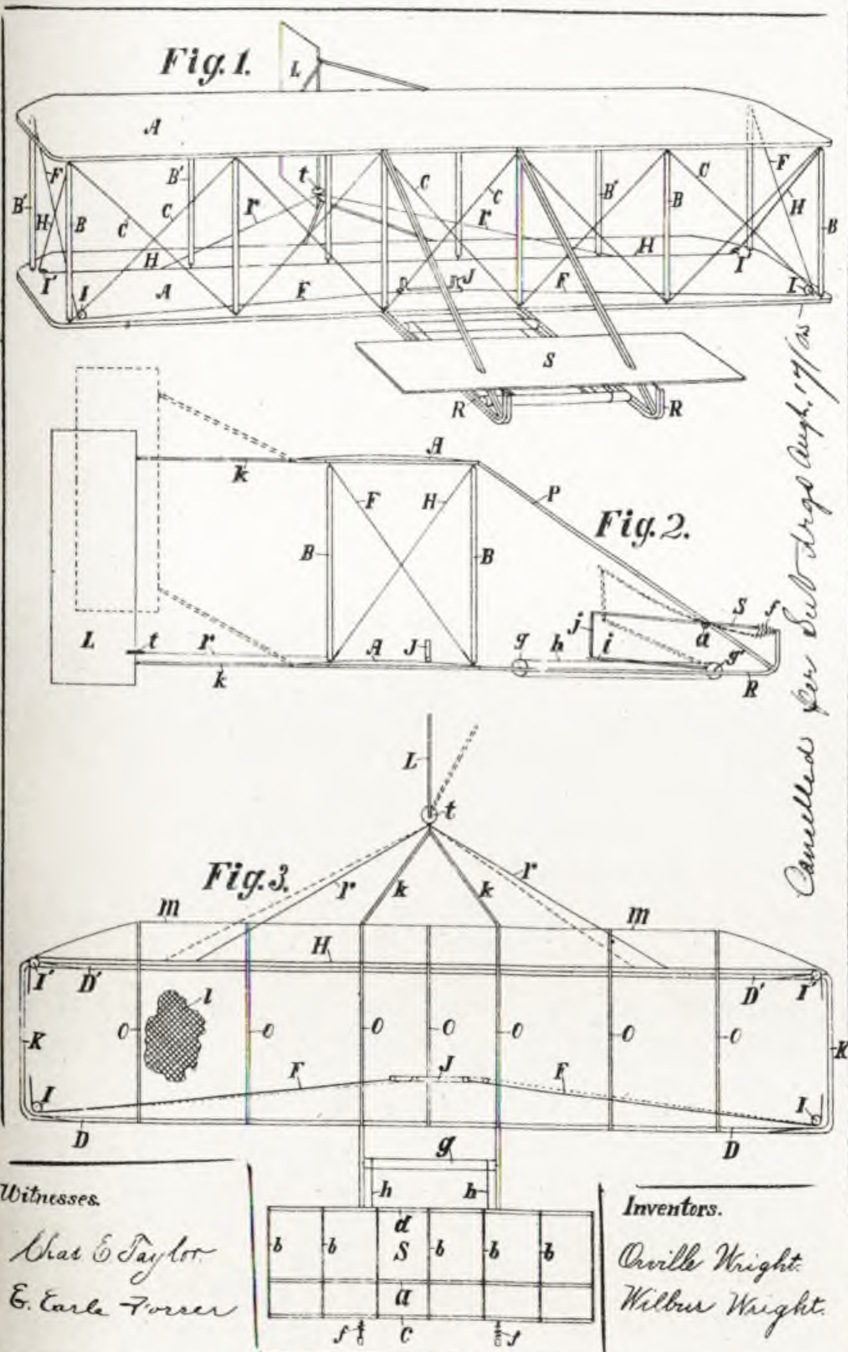
PNEUMATICS
Aerial Navigation.

Serial No. 14220 Div. 28
Sheets-Sheet

Fig. 1.

Fig. 2.

Fig. 3.



Cancelled per Sub drgs Aug. 17/05

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, 190

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County of

State of Ohio.

, filed

Invention

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Division of App., No.

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DEFENDANTS' EXHIBIT "GLIDING EXPERIMENTS".

UNITED STATES CIRCUIT COURT
WESTERN DISTRICT NEW YORK.

ORVILLE WRIGHT & WILBUR WRIGHT
vs.
HERRING-CURTISS COMPANY
and
GLENN H. CURTISS.
In Equity #400

Defendant's Exhibit
GLIDING EXPERIMENTS.
Beatrice Minis
Notary Public. N. Y. C.

GLIDING EXPERIMENTS.

—BY—

OCTAVE CHANUTE, C. E.

MEM. W. S. E.

Reprint from Journal Western Society of Engineers.

1897.

U. S. CIRCUIT COURT.
WESTERN DIST OF N. Y.
FILED

DEC 14 1909

HARRIS S. WILLIAMS.
CLERK.

XX. 593

GLIDING EXPERIMENTS.

An Address* by Octave Chanute, C. E., Mem. W. S. E.

Delivered 20th of October, 1897.

Mr. Chanute stated in beginning that when, in 1891, Professor Langley, the eminent astronomer, and the secretary of the Smithsonian Institution, published his important work, "Experiments in Aerodynamics," the closing paragraph of the summary was as follows: "I wish, however, to put on record my belief, that the time has come for these questions (i. e., those of aerodynamics and aerial navigation) to engage the serious attention not only of engineers, but of all interested in the possibly near practical solution of a problem, one of the most important in its consequences of any which has ever presented itself in mechanics; for this solution, it is here shown, cannot longer be considered beyond our capacity to reach."

Mr. Chanute continued that it did not seem to the general public then, and it possibly might not seem now, as if a commercial and practical flying machine was an achievement to be expected in the near future; yet it did seem opportune for an engineer approaching the end of his professional career to devote some of his leisure to the investigation of the laws which must be hereafter observed by other engineers in compassing the navigation of the air. He therefore took up the question; and believing that the surest method is first to study past failures in a novel undertaking, he made an investigation of the records of all the experiments, which had been tried during the last two or three hundred years, in the endeavor to imitate the birds. This resulted in a number of technical articles which swelled into a book, in which the attempt was made to eliminate the causes of each failure; for up to that time there had been nothing but failures.

He said he had hitherto abstained from addressing his fellow engineers on the subject, as some might deem it premature. but he had become gradually convinced, not only through investigation but through practical experiment, that it was not only possible but almost certain that man will eventually be enabled to make his way through and on the air by dynamic means, although it might require a considerable and long process of evolution to do so. This evolution was now in progress, and very great advance has recently been accomplished. It chanced that about the year 1888, a number of able men, in various parts of the world, simultaneously took up the question, and the progress

*Illustrated by lantern slides.

Sample

which they have made is already greater than that previously achieved during the past two or three centuries. Those men were Mr. Maxim, an American in England, Professor Langley in this country, Mr. Hargrave in New South Wales, and Mr. Lilienthal in Germany. They investigated afresh the laws which underlie the possible solution of the problem of flight, and the results of their labors will probably best appear from a discussion of the various elements of that problem.

These elements number ten at least, and may be considered as so many subsidiary problems, each to be solved separately, perhaps in more ways than one, and those solutions then to be combined into a harmonious whole. They may be stated as follows:

1st. The Supporting Power and Resistance of Air.

This first problem is the foundation of the whole subject, and, singularly enough, it is only within the last six years that it has been settled beyond question what is the true measure of those properties of air when meeting a surface at an oblique angle of incidence. Sir Isaac Newton gave by implication from his proposition XXXIV, Book 2 of the Principia, a law which has variously been intrepreted as meaning that normal fluid pressures vary as the sine, or the square of the sine of oblique incidence. These formulae are today still taught in the schools, and found in text books, although experiments have shown that at very acute angles they give from one-tenth to one-twentieth of the true results. Engineers make current use of them in calculating pressures upon roofs, and upon parts of bridges struck obliquely by the wind, while with later knowledge it can be shown that a wind gust deflected upward under the floor of a bridge, even so little as 5 or 10 degrees, produces such a lifting effect as to account for the blowing off of superstructures hitherto accounted as inexplicable. In point of fact, Professor Langley's experiments showed that oblique air pressures varied not as the sine, or the square of the sine of incidence, but, approximately as indicated in the empirical formula proposed by Col. Duchemin about 1828, in which the relation between the rectangular normal pressure and the oblique normal pressure is represented by:

$$P = P' \times \frac{2 \text{ Sine } \alpha}{1 + \text{Sine}^2 \alpha}$$

In which $P =$ the oblique pressure.
$P' =$ The rectangular pressure.
$\alpha =$ The angle of incidence.

This applies exclusively to planes or flat surfaces, while Lilienthal has shown by experiment that curved surfaces presented with their concave side to the wind afford still greater pressures, these being from twelve times to four times the normal pressures obtaining upon planes at angles between 1 and 5 degrees, which are those most favorable for flight. Thus it is that we are now enabled to calculate with some confidence the support which may be obtained by gliding at any given speed upon the air, and the power required to overcome the resistance. An eminent French mathematician, at the beginning of this century, calculated that a swallow, weighing six-tenths ounces, expended in full flight no less than one-thirteenth of a horse-power. This calculation was evidently erroneous. It would have implied that the weight of a man, say 150 pounds, would require the expenditure of something like 300 horse-power to sustain it in the air, but calculations of the power really required could not be made with confidence until the recent labors of Professor Langley, confirmed as they have been by those of Mr. Maxim, and the still more encouraging coefficients for concave surfaces obtained by Lilienthal and in the experiments which were to be presently described.

2d. THE MOTOR, ITS CHARACTER AND ITS ENERGY.

This second problem, now nearly solved, was thought until five years ago to be still more difficult than the obtaining of supporting power from the air. It was known that the motor muscles of birds, though possessing but little more tensile strength than those of land animals, gave out energy at a much more rapid rate, so that it was variously estimated that bird machinery (muscles) weighed from 5 to 20 pounds for one horse-power exerted. Upon investigation in 1890, it was found that the lightest steam engines then in use were those in launches and weighed 60 pounds per horse-power, that the lightest petroleum engines weighed 88 pounds per horse-power, while the lightest electric motor weighed 130 pounds, and the lightest storage battery and dynamo weighed some 200 pounds per horse-power hour. Since then the advance has been very great. Mr. Maxim has produced a steam-plant of 360 horse-power which weighs about 8 pounds per horse-power. Professor Langley has built an engine and boiler which weighs 7 pounds and exerts one horse-power, while Mr. Hargrave has constructed a steam engine weighing about 10 pounds to the horse-power. Almost as great advances have been accomplished with petroleum motors, which possess the great merit of dispensing with a boiler, so that for the first time the realization of a sufficiently light motor for a dynamic flying machine seems to be within sight. It now seems probable that this will be accomplished with a petroleum engine when the eccentricities now inherent to that class of unperfected motors have been overcome in practice.

3d. THE INSTRUMENT FOR OBTAINING PROPULSION.

The third question relates to the device through which adequate thrust shall be obtained by action upon the air. All sorts of contrivances have been proposed; reaction jets of steam or of compressed air, the explosion of gunpowder or even nitro-glycerine, feathering paddle wheels of varied design, oscillating fins acting like the tails of fishes, flapping elastic wings like the pinions of birds, and the rotating screw. Mr. Maxim and Professor

1923

Langley have made many experiments to determine the best form, speed and pitch of the screw to obtain thrust from the air, and have materially improved that instrument, which, to reason from analogy in land and water transportation, seems likely to prove the best device, but both Mr. Hargrave and Mr. Lilienthal have obtained very favorable results with the flapping pinion, which requires no intervening machinery to change the reciprocating action of a piston into a rotary motion, and it seems perhaps possible that success in artificial flight may be obtained with either or both devices.

4th. THE FORM AND KIND OF THE APPARATUS.

This fourth question has elicited great divergence of views among the designers of flying machines. Almost numberless projects have been advanced, but they can all be classified under three heads. 1st. Wings to sustain and propel. 2d. Rotating screws to lift and propel, and 3d, aeroplanes or aerocurves, to consist of fixed surfaces driven by some kind of propelling instrument. The first two have been the first to be proposed and experimented with. They have many warm advocates at the present time, but the practical experiments made within the last five years seem to indicate that success will first be achieved with aeroplanes, or to state it more accurately, by coining a new word, with *aerocurves*, which have been shown by Lilienthal to furnish much greater lifting reactions. The following table, in which the weight of the operator of a one-man machin is included with the weight of the apparatus, approximately indicates the comparative merit which our present knowledge enables us to assign theoretically to these three varieties of flying machines.

Comparative efficiency of various forms.

Kind of Apparatus.	Pounds probably sustained per Horse-power.	Proportion probably available for motor.	Resulting possible weight of motor per Horse-power.
Screws	25	17 per cent	4 lbs
Wings	80	10 per cent	
Aerocurves	80	17 per ce	

It will be noticed that this involv light in proportion to their ou other supplies must also be but yet that the desired resu almost in sight.

5th. THE EXTENT OF THE S

The fifth problem, relating support the weight of a man, versy and gathering of data. quence of the law inherent t as the squares, and the weights dimensions; it might well be t due to the greater leverage sho any larger flying machine than so long ago that a distinguishe

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divine will, though that is the natural inclination of the soul. God wooes us in that direction by the gentle promptings of his Spirit until we make our decision to serve God and him only, and then gives us all the strength we need to carry out our resolve. It is for man to choose, and for God to do the rest; it is for man to obey, and for God to work out his eternal salvation.

Joshua's Decision.

The old leader doubtless waxed eloquent at this point, closing his marvewhich he flatly took the ground that an artificial flying machine was impossible for three reasons: 1. That Nature, with her utmost effort, had failed to produce a flying animal of more than fifty pounds in weight. 2. That the animal machine was far more effective than any that man may hope to make. 3. That the weight of any artificial flying machine could not be less, including fuel and engineer, than 300 or 400 pounds. These assertions have since been modified, but the author still holds that the possible limit of weight cannot be pushed much, if at all, beyond 100 pounds of machine and operator together.

In point of fact, flying creatures vary in extent of supporting surface from about 40 square feet to the pound in the butterfly, to an area of 44-100 square feet to the pound in the duck. The amount required depends upon the speed of the creature's flight, the larger soaring birds generally spreading about one square foot or less to the pound, while the experiments of Lilienthal, as well as those to be hereafter described, have demonstrated that a man's weight can be well sustained, at 22 to 25 miles an hour, by an apparatus spreading three-quarters of a square foot to the pound, and that this apparatus need not weigh more than from 23 to 36 pounds, without motor or propeller, so that if the latter weigh some 60 pounds more, we may fairly expect to compass a dynamic machine with a weight of about 100 pounds, carrying a man of about 150 pounds, upon sustaining surfaces of rather less than 200 square feet in area.

6th. THE MATERIAL AND TEXTURE OF THE APPARATUS.

The sixth question relates to the material to be selected for the framing of the machine, for the motor, and to the texture of the sustaining surfaces. Nature accomplishes her purposes with bone, flesh and feathers, but man has at his command metals, fuel and textile fabrics. Many hopes were expressed some years ago, when aluminum first became a commercial metal, that it was about to solve the problem of aerial navigation. Later investigations have developed the fact that aluminum is as yet inferior to steel per unit of weight. It is lighter, but it is also weaker. For a beginning wood will do very well. It is a fact, realized by few engineers, that the best woods, so long as they remain undecayed, are actually stronger in proportion to their weight than the ordinary grades of steel. Wood is easily and cheaply procured and shaped, and whatever success has hitherto been had in gliding flight has been accomplished with wooden frames covered with textile fabrics. The latter are probably inferior in efficiency to the ribbed surface of feathers, as quite recent experiments tend to show, but they will answer for a beginning.

Thus we see that six out of the ten subsidiary problems involved in the general question have been approximately solved. Not all, but most of this has been accomplished within the last few years. The remaining four problems are more difficult of solution, but even towards this, gratifying advance has been made.

7th. The Maintenance of the Equilibrium.

The seventh problem relates to the stability of the apparatus in the air, and especially in a wind. This equilibrium must be maintained at all angles of incidence and under all conditions of flight and of wind, in rising, in sailing and in coming down. The first requisite for this is that the center of gravity shall constantly be in a vertical line with the center of pressure, and unfortunately the latter is almost constantly varying with the relative wind, with the speed and with the angle of incidence. It is a peculiarity of air pressures, ascertained by experiment, that as the angle of incidence changes, the position of the resultant center of pressure also changes. When air meets a surface at right angles, the center of pressure coincides with the center of that surface, but when the angle becomes more acute, the center of pressure moves forward until it approaches a position about one-fifth of the distance back of the front edge on a plane. This movement is approximately expressed by what is known as Joessel's formula for square planes:

$$C=(0.2+0.3 \operatorname{Sin} \alpha)L.$$

In which C=The distance from the front edge.
L=The whole length fore and aft.
α=The angle of incidence.

This formula is found not to be accurate for oblong planes, and even not strictly true for square planes, but it is understood that recent experiments are likely to produce a more accurate formula for planes. The great need, however, is for a formula which shall accurately express the movements of the center of pressure on concavo-convex surfaces. They are known to present some curious anomalies, but no physicist, so far as is known, has yet reduced them to the reign of law. The problem of stability may be said to have been very considerably advanced. The experiments hereinafter to be described were undertaken with the sole view of evolving the solution of this question, for it is held to be of the very first importance. Far more so than seems to be realized by experimenters; for until automatic equilibrium is secured, and safety is ensured thereby, under all circumstances, it will be exceedingly dangerous to proceed to apply a motor and a propeller. Birds preserve their balance by instinct, by skill acquired through long evolution and tentative practice. Man will have to work out this problem thoroughly, even to the temporary disregard of the others, if he is ever to make his way safely upon the air.

8th. The Guidance in any Desired Direction.

The eighth problem relates to the steering. It has been generally supposed that this would be best effected by horizontal and vertical rudders, but the experiments of Lilienthal, and those to be here described, have shown that slight changes in the position of the center of gravity are more immediate and effective. This problem cannot be said to be fully worked out, but it is not deemed to be very arduous. We already know that a gliding machine is exceedingly sensitive to the least change in the position of the weight or of the rudders, and therefore that it will be easily controlled by slight movements, if they are accurately made.

9th. The Starting up Under all Conditions.

The solution of the ninth question as to the best methods of starting away from the ground is likely to be one of the last to be practically worked out. It will require a great deal of experimenting and ingenuity to devise means for rising from a level under all conditions. This is a task for the future. Meanwhile it is easy by special appliances, or by starting from an eminence in the wind, to get a machine into the air so as to work out the more immediate problem of stability.

10th. The Alighting Safely Anywhere.

The tenth problem relates to the alighting. It is the one which always produces a smile upon its bare enunciation, probably in remembrance of that little experiment of Darius Green. It may be said to be as yet unsolved for the dynamic machine of the future, and yet, both Lilienthal's experiments and those to be now described showed this problem to be very easy of solution with a gliding machine, by simply making use of increased air resistance at greater angles of incidence to stop the headway before alighting on the ground.

Lilienthal probably accomplished more towards a practical solution of the general problem of flight than any of the previous experimenters. He was an accomplished engineer and mathematician, an ingenious inventor and a skillful experimenter. The first thing which required to be practically demonstrated was that a man's weight could be safely carried by gliding upon the air, and that he could alight safely. Lilienthal was the first man to produce these results and to reduce them to current practice. He made thousands of glides in safety, until the one dismal occasion in August, 1896, when a defect in his apparatus, probably the breaking of a wire, produced the fatal fall that deprived the world of his services and life. It is true that other men had safely descended in parachutes, that Mr. Maxim has made a short flight upon a dynamic machine, and that Mr. Hargrave has ascended a short distance under a team of kites, but Lilienthal was the first to demonstrate by repeated experiments that man could glide upon the air like a bird, and he will hereafter be recognized as the pioneer who indicated a method through which final success may eventually be won.

Continuing, Mr. Chanute said that when all the problems which he had indicated were solved—and it had been shown that many of them were partly if not wholly solved—they would still have to be combined into one harmonious design before a commercial flying machine was produced. It would therefore be conceived that a good deal of experimenting will be required, and that such experiments will be fraught with danger. He had nevertheless advised in his writings, and in an article in the Engineering Magazine for April, 1896, that experiments be carried on preferably with full sized machines, carrying a man, as the more fruitful and instructive method. This was good advice, but it might prove dangerous for others to follow. He therefore deemed it desirable that he should ascertain himself how much of risk this involved, if made with due care and precaution.

It was not the intention, in these experiments, to seek to invent a flying machine, although that impression may have been conveyed by some of the newspaper notices of them. The intention was mainly to study the seventh problem—the maintenance of the equilibrium—which it was hoped to gain automatically. This it was expected to do by reversing the method of Lilienthal, who moved his bodily weight to bring back the center of gravity under the center of pressure, as fast as the latter shifted from any cause. It had occurred to Mr. Chanute that it might be preferable to provide moving mechanism within the apparatus itself, to shift the surfaces so as to bring back the varying center of pressure over a fixed center of gravity; and that in such case the operator need not move at all, except for the purpose of steering. The results have been exceedingly gratifying. Two forms of apparatus have been evolved, each equipped with a different device, which are now believed to be materially safer than any heretofore produced. With them several hundred flights have been made, extending over two seasons, without the slightest personal accident.

In December, 1895, Mr. Chanute secured the services of Mr. A. M. Herring, a civil and mechanical engineer, who had for some years been making experiments in Aviation, this being the recent name given to attempts to imitate the birds. The first thing done, after some groping with models, was to build a kite, in order to test the stability of the proposed gliding machine. This was called the "ladder kite," from its resemblance to a step-ladder in one of its postures, for it was so constructed as to admit of grouping its surfaces in various ways. This kite proved exceedingly stable, flying in gusty winds without the eccentricities common to that class of apparatus. Then the construction of a similar machine was begun, which was capable of carrying a man, but first Mr. Herring rebuilt a machine, previously tested by him in New York, somewhat similar to that of Lilienthal, so that the known should be tested before passing to the unknown. With these two machines Mr. Chanute and Mr. Herring, and two assistants (Mr. Avery and Mr. Butusov), went in June, 1896, to the desert sand dunes at the south end of Lake Michigan, north of Miller Station, about thirty miles from Chicago. The Lilienthal-like machine was the first tested.

FIG. 222. Modified Lilienthal Machine.

The Figure 222 represents Mr. Herring in the Lilienthal type of apparatus, poised in a wind at the top of a sand hill about thirty feet high, preparatory to making a glide. The machine spread 168 square feet of sustaining surface, was equipped with a double rudder, and weighed thirty-six pounds. With this about 100 glides were made, the longest being 116 feet. It proved from the outset an awkward machine to handle. Lilienthal, whose skill had been developed by four or five years of practice, obtained valuable and safe results with it, but it was otherwise with novices. Its operation involved a struggle with the wind before it could be brought under control, and this continued after the flight had begun.

In Fig. 223 this machine is shown gliding a short height over the ground. This was practiced to avoid untoward accidents, for the winds experimented in, of 12 to 17 miles per hour, constantly varied the position of the center of pressure so far and so rapidly through their fluctuations, that the operator had to shift his position as actively as a tight-rope dancer, but to greater distances, to avoid being overturned. The body had to be moved at times some 15 or 18 inches, and not infrequently in landing the apparatus was broken. This involved less personal risk than might be supposed, because the radiating ribs curve downward as shown,

FIG. 223. Lilienthal Type Under Way.

so that they first come into contact with the ground when an awkward landing is made, and save the operator from harm. Similar experience seems to have obtained with an acrobat in a public garden in Vienna, with Professor Fitzgerald in Dublin, with Mr. Lamson in Maine, and with the *Journal* newspaper in New York, although Mr. Pilcher, in England, has succeeded well with a modified Lilienthal apparatus of his own building. At last, the machine shown on Figs. 222 and 223, after having been broken and mended a number of times, was finally discarded altogether, and within six weeks thereafter Lilienthal's sad death occurred while experimenting with his double-decked apparatus.

After abandoning this first form of machine, the experimenters in the sand dunes next tested the machine built after the fashion of the ladder kite which had proved so steady in the air.

Fig. 224 exhibits a front view of this arrangement. It consisted of six pairs of wings, superimposed and trussed together, pivoted at their roots upon a central frame, the lower chord of which was spread open to receive the man at the center. Here he was expected only to move for the purpose of steering, the stability to be maintained by the movements of the wings above him, which swung on their pivots back and forth, restrained by rubber springs, when the wind struck one side more than the other, or changed the center of pressure fore and aft. It will be seen that this is just the reverse of the first method tested, in which the man moved and the wings remained fixed. This wing movement took place as expected, but it was very soon found that there was an essential difference between the support from the wind derived from the same arrangement when flown as a kite, at an angle of incidence of 30 to 40 degrees, and when flown as a glid-

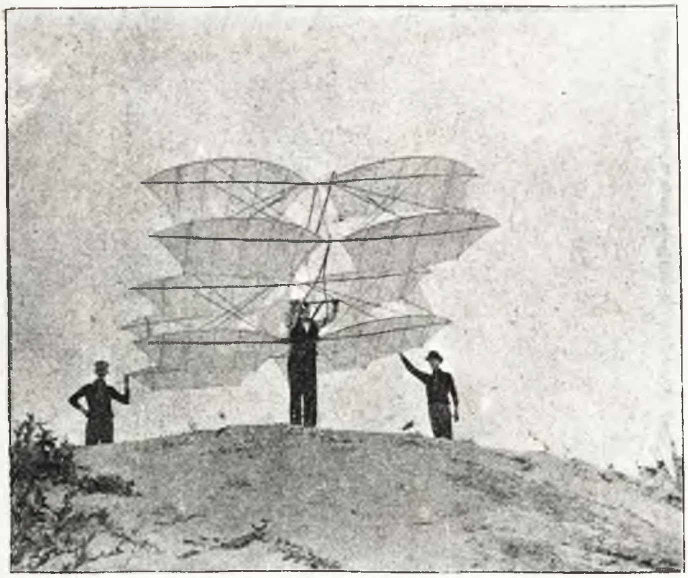

FIG. 224. First Form Multiple-Wing Machine.

ing machine, at an angle with the wind of three or four degrees, which is the most favorable for reducing the total resistance to a minimum. It was found that at very acute angles the moving air was deflected downward by the front wings, so that the support under all the following wings was greatly diminished, and that the apparatus was inefficient when its surface was considered. This had been expected, from prior experiments, and the frame had been designed so that the grouping of the wings could be readily changed. Then began an interesting and instructive evolution. The grouping of the wings was gradually changed, through six permutations, each being guided by gliding flights and by releasing bits of featherdown in front of the machine, and watching the paths of the air currents which swept past the wings. The result of this evolution was to change greatly the outward appearance of the apparatus while retaining the same general principle.

Fig. 225 shows the improved arrangement as seen from one side in flight. It will be noticed that no less than five of the six pairs of wings have been superimposed at the front, and trussed together. That the operator is within and under them, and that a single pair of wings remains at the rear to serve as a tail. This tail was flexible and vibrated up and down in flight when the angle of incidence varied in consequence of the back and forth movements of the pivoted front wings.

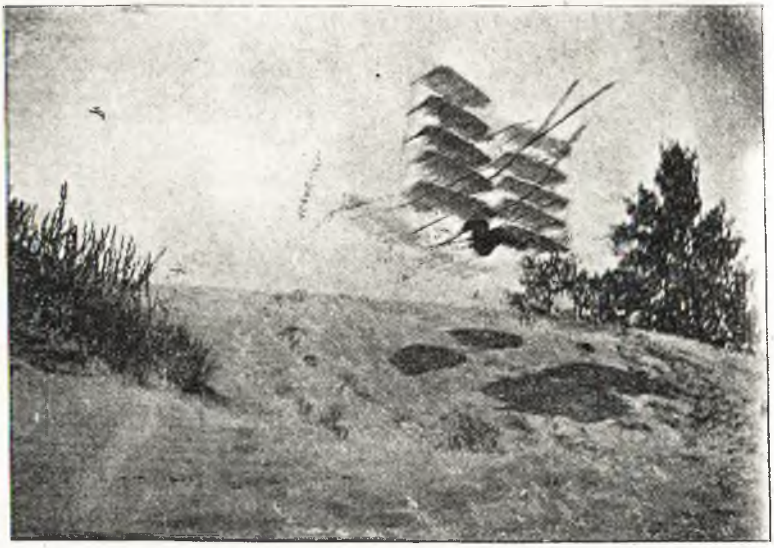

FIG. 225. Sixth Form Multiple-Wing Machine.

Fig. 226 shows a front view of the same machine in flight. About two hundred glides were made, in winds of 13 to 22 miles an hour, on a descending course of about 1 in 4 (14°), the longest flight being 82 feet from a height of about 20 feet. There was, however, undue friction in the wing pivots, thus retarding their

FIG. 226. Front View Multiple-Wing Machine in Flight.

automatic action, so that the operator had to move two or three inches, as against some 15 or 18 inches on the previous machine, and there being some further defects in the spacing of the wings, both vertically and horizontally, it was determined to rebuild the machine with the practical information thus obtained.

Camp was accordingly broken up early in July, with the conviction that more had been learned during this two weeks of experiment with full-sized machines than had previously been acquired during about seven years of theoretical study and experiments with models. The equipment was returned to Chicago, where three machines were constructed, and towards the end of August they were taken out to the wilderness of sand dunes, north of Dune Park, about five miles from Miller.

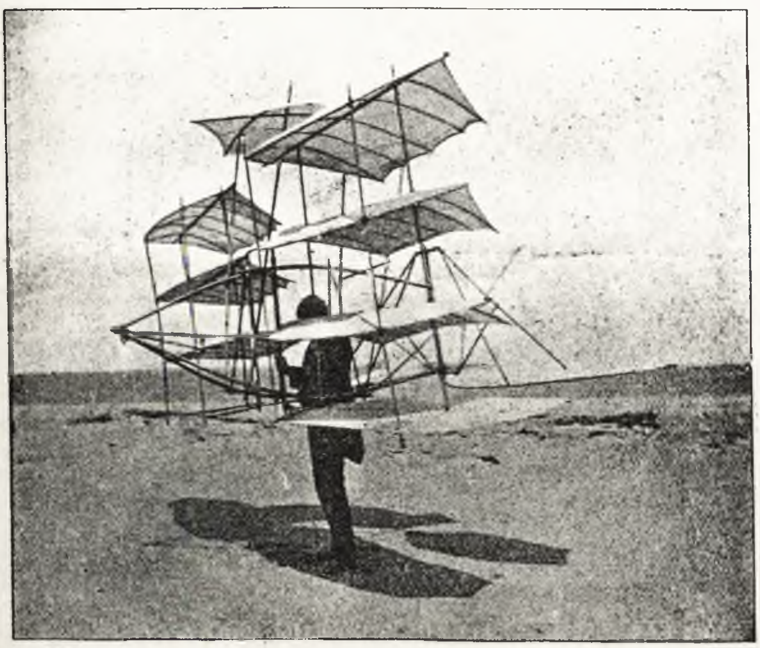

FIG. 227. Seventh Form Multiple-Wing Machine.

Fig. 227 shows the multiple-wing machine as reconstructed. This consisted of the same wings and of a new frame, and instead of ordinary pivots, there were ball bearings at the ends of vertical wooden posts to which the roots of the wings were attached, the latter being all trussed together, with vertical posts and diagonal wire ties, this being probably the first application which has been made of the Pratt truss to flying machine design. The frame was all made of spruce, the surfaces were of Japanese silk varnished with pyroxelene; the complete machine weighed 33½ pounds,

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the supporting surface at the front was 143½ square feet, including a concave aerocurve over the top, added when the front wings were cut down to four pairs, and the rear wings or tail measured 29½ square feet in area. With this arrangement a great many glides were made, with the result of more than doubling the lengths previously attained, of reducing the angle of flight to 1 in 5, or 10° to 11°, and of diminishing the required movements of the operator to one or two inches in preserving the equilibrium.

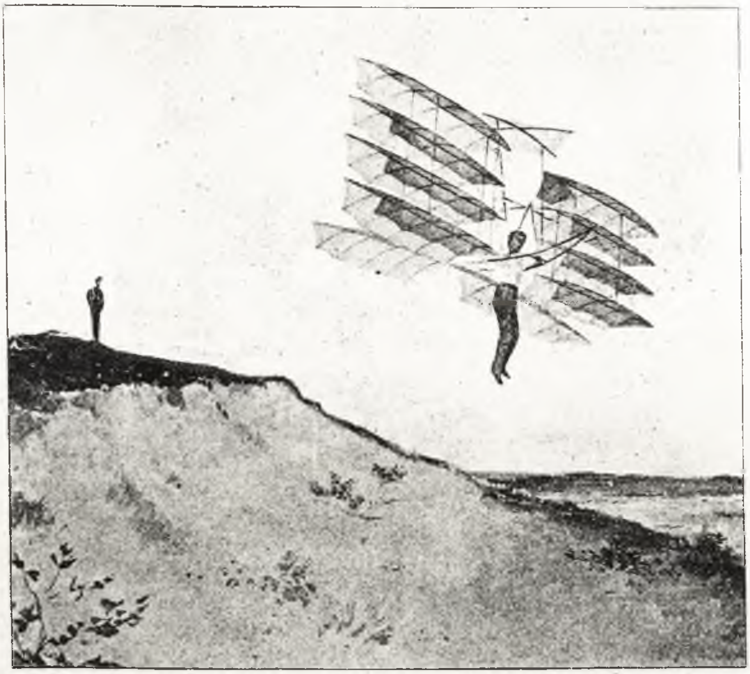

FIG. 228. Multiple-Wing Machine in Flight.—(From a drawing.)

Fig. 228, reproduced from a drawing, shows this apparatus as it appeared in flight. It might have been preferable to omit the aerocurve over the top, and to have placed all the supporting surface in the pivoted wings at the front. This aerocurve was added to save the expense of rebuilding the old wings, and this saving proved to be a mistake. The wings were so far racked and distorted by their prior service that they did not support alike and did not balance the weight properly, and thus the results obtained with that machine were inferior to those to be hereafter described. Yet the principle is deemed to be sound, and it is believed that the apparatus can be further improved.

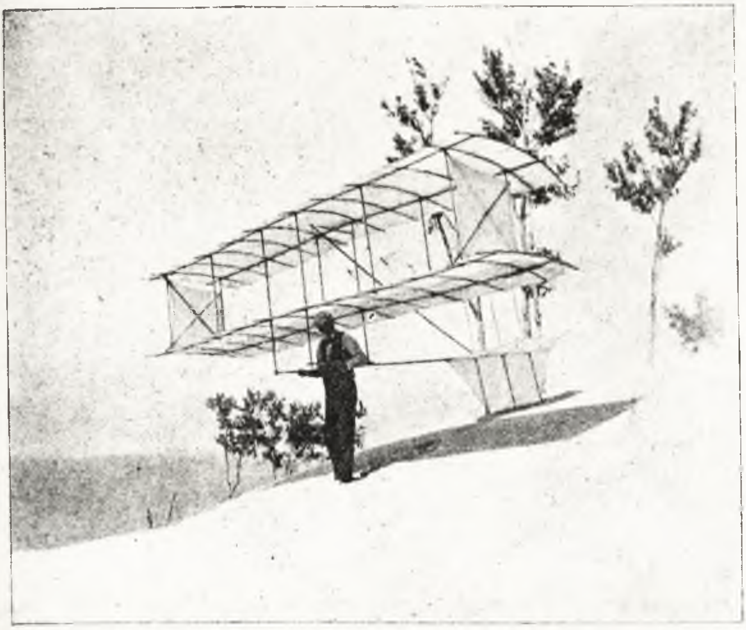

FIG. 229. Two-Surfaced Machine with Side Keels.

Fig. 229 exhibits the next full-sized machine which was built. It is seen to be very simple in construction, and to consist in a single intersection Pratt truss carrying the surfaces, to which was applied a regulating mechanism designed by Mr. Herring. This truss will safely support 300 or 400 pounds applied to the arm bars at the center. In calculating its proportions a basis has to be adopted which is the reverse of that which obtains in the calculation of bridges, for the support, or air pressure, has to be considered as uniformly distributed, and the load has to be figured out as concentrated at the center. It may be mentioned in this connection that one practical difficulty found has been in devising some method of adjustable connection between the vertical posts and the diagonal ties. The latter are from two to five hundredths of an inch in diameter, and it is not practicable either to cut a screw upon them for a nut, nor to apply a sleeve nut or a turnbuckle. Perhaps some engineer will suggest a better device than the loop heretofore used, which is made by twisting the wire back upon itself, and which is not adjustable.

With this apparatus as shown in Fig. 230, several hundred glides were made, varying in length from 150 to 360 feet, at angles of descent of 7½ to 10 degrees, and during the six weeks occupied with the experiments, not the slightest accident occurred either to the operators or to the machines. The regulating mechanism

FIG. 230. Two-Surfaced Machine Just Starting.

took care of the equilibrium fore and aft and diminished the effect of the side wind gusts which were then easily overcome by slight side movements of the operator. Towards the last amateurs were permitted to try it under instructions. They made fair glides in safety. One or two cruises by newspaper reporters, and another by a novice, who was picked up by the wind and raised some forty feet into the air, but who landed almost in his tracks as gently as if he had only fallen from the height of a chair.

Fig. 231 shows a side view of this apparatus in flight. On this occasion a glide was made of about 300 feet at a height of ten to twenty feet above the ground, but it was not uncommon for the machine to sail forty or fifty feet above the ground, and to pass over the heads of the spectators. The whole apparatus spread 134 square feet of supporting surface, weighed 23 pounds, and thoroughly supported the weight of a man at speeds of about 23 miles an hour. A piece of trestle work will be observed in the background. This was used to launch the machine which is next to be described.

Fig. 232 exhibits the fifth full-sized apparatus which was experimented with in 1896. It was the invention of a Russian, who claimed that he had already attained success in soaring flight with it, and as this closely resembled the machine of Captain Le Bris, who was said to have sailed with such a machine in France,

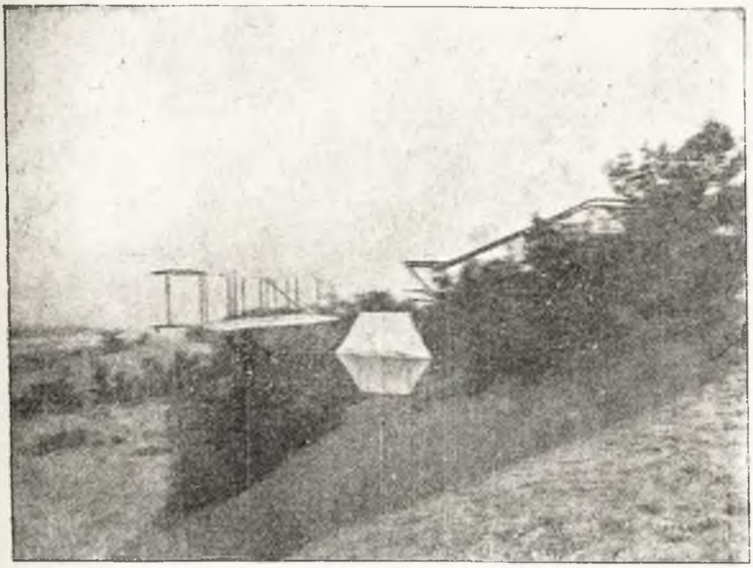

FIG. 231. Under Way and Level with the Starting Point.

in 1867, it was determined to give the design a trial. It was a somewhat complicated apparatus. Over the top was an aero-

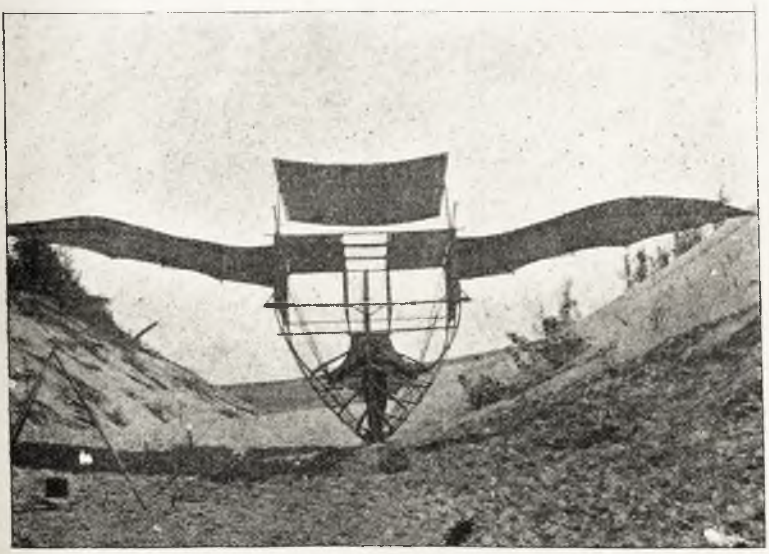

FIG. 232. The Albatross Machine.

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plane, below which two great wings extended, 40 feet across, and beneath which again there was a boat-like frame which could be transformed into a skiff by enclosing it with oiled canvas. The whole spread of supporting surface was 266 square feet and it weighed 190 pounds. As this could not, like the other machines, be carried about on a man's shoulders, special appliances were required to launch it.

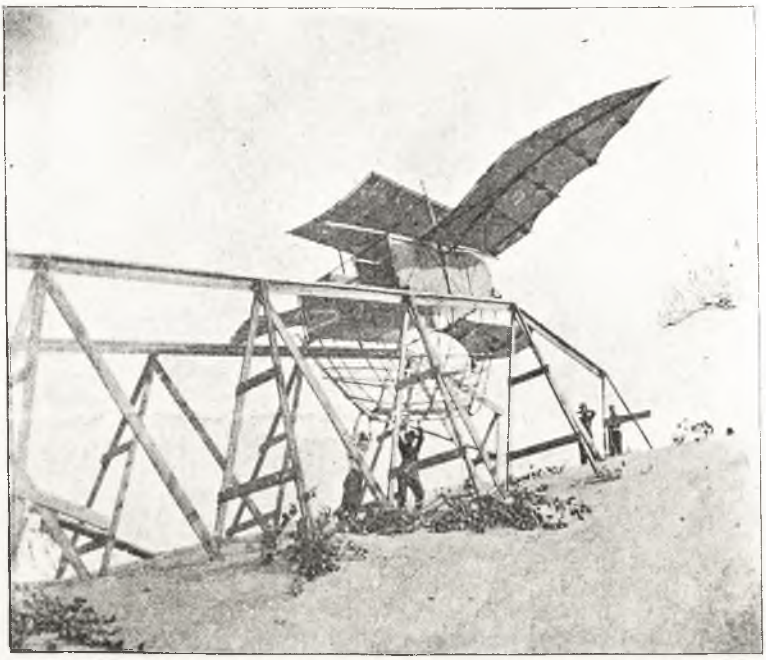

FIG. 233. The Albatross on the Ways.

This appliance is exhibited by Fig. 233, and consisted of trestle work built down the slope of the hill. It involved the great disadvantage that it could only be used when the wind blew straight up the trestle, a rare occurrence. Nevertheless two launches were made, but in ballast, as there was no absolute certainty about the equilibrium. On the first occasion, with 130 pounds of ballast, it went off very well indeed, but did not sail very far. In alighting, some of the ribs of the boat-frame were cracked, but were replaced in an hour. On the second trial, with 90 pounds of ballast, but in a quartering, unfavorable wind, the latter swung the machine around, after it left the ways, and upon one of the wings striking a tree, the apparatus fell and was broken. On neither occasion would the operator have been hurt had he been in the machine, but it was evidently much too heavy and too cumbrous to be successfully used in experiments designed solely to work out the problem of equilibrium.

This ended the experiments of 1896. A fuller account will be found in the "Aeronautical Annual" for 1897, edited by Mr. James Means, of Boston, whose publications during the last three years have done very much towards advancing the study and solution of the problem of Aviation. Detailed plans of the multiple-wing machine will be found in the 1897 issue.

The results of these experiments in 1896 were to develop two machines which are believed to be safer than any others previously tried. To advance materially the solution of the problem of equilibrium. To learn much about the management of flying apparatus in the wind, and to determine with some accuracy the power required. For this purpose the lengths and heights of some of the flights were measured. They were also timed, and it was found that the power expended was from 619 to 789 foot-pounds per second, or 1.13 to 1.43 horse-power to sustain 178 pounds in the air. This, however, was in a rising trend of wind. In nearly calm air, the power expended was found to be 2 horse-power, or at the rate of 89 pounds sustained per horse-power.

FIG. 234. Getting Ready.

This represented the actual thrust required to be exerted by a propeller. If we assume the latter to possess only an efficiency of 70 per cent, then we should require 2.85 actual horse-power on the shaft, and if the internal friction of the engine diminished its efficiency to 70 per cent of its indicated horse-power, then a motor of about five indicated horse-power might be expected to maintain an apparatus of the above type, carrying a man, in horizontal flight through the air. A result which is surely encouraging.

Mr. Chanute continued by saying that in 1897 he had inaugurated experiments with models for the purpose of testing still a third method of obtaining automatic equilibrium, but that these had not proceeded very far. That Mr. Herring, having been requested by an amateur to supply him with a gliding machine, had built a new one with his regulating mechanism, and that the pictures next to be shown had all been taken from flights made with that apparatus, it having been tested at Dune Park in September, 1897.

Fig. 234 exhibits the machine at the top of the hill, preparatory to making a glide. It is a common saying that a child must creep before he learns to walk, and something of the same required training obtains with a flying machine. The operator (Mr. Herring in this instance) is seen creeping under the machine in order

FIG. 235. Poised for Flight.

to rise with it, when lifted up by the two assistants, and to place himself within the arm bars.

Fig. 235 shows the apparatus poised in the wind. This involves generally a struggle with the breeze, which buffets the surfaces either from one side or the other, or fore and aft. A skillful operator resists this by bracing the machine against his back and keeping the front edge depressed, facing the wind accurately. As soon as this poise has been obtained, two or three running steps are taken, the front edge is slightly raised, and a leap is taken forward.

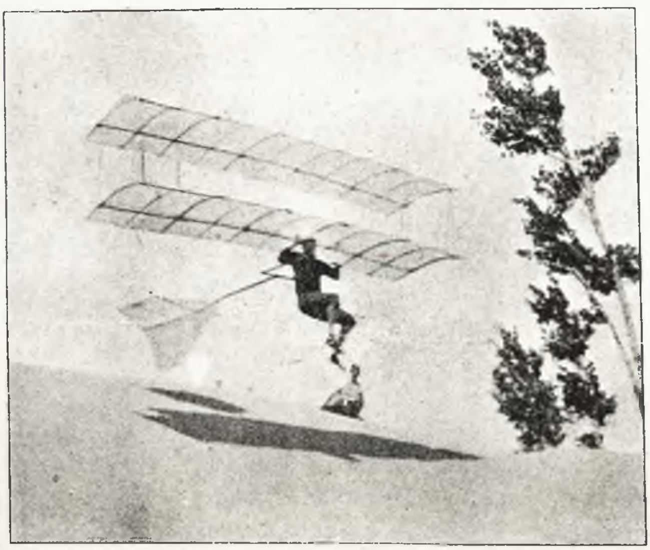

FIG. 236. The Flight Begun.

Fig. 236 shows the result, which is that the man is lifted up and supported by the air, and then sails forward at a slightly descending angle, the motive power being furnished by gravity, and the supporting power, which is due to the speed, being assisted by the adverse wind.

Fig. 237 exhibits the machine as thoroughly under way, the regulating mechanism providing for the fore and aft equilibrium, which is the most precarious and productive of accidents. If the wind be steady, and the operator has placed himself at just the right point within the arm bars, the glide might continue without any movement on the man's part, but there are incidents which are apt to occur in consequence of the irregularity of the wind, such as that shown in the next picture.

In Fig. 238, the apparatus is shown as struck by a side gust The illustration in this particular picture was somewhat exagger

Fig. 237. Well Up.

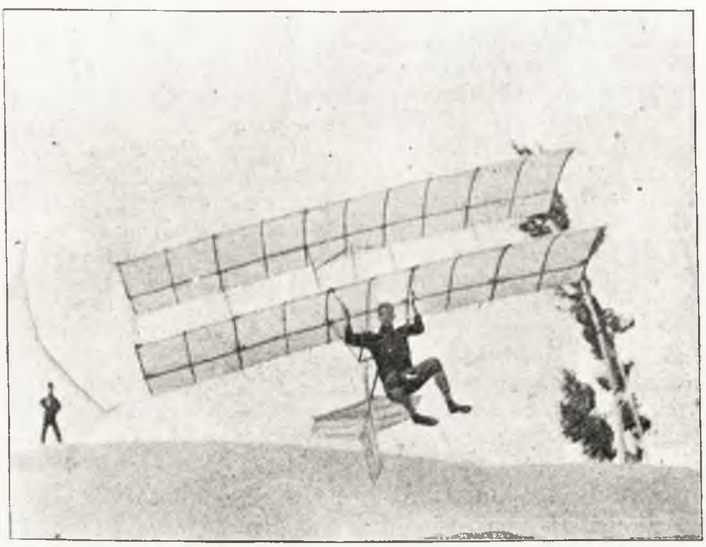

Fig. 238. Struck by a Side Gust.

ated by the tact that the camera was not held quite level, but it is clear that the left wing has been raised by the gust, and that the operator has thrown his feet towards that side, in order to bring the wing down. It may be well here to remark that when in flight the bodily movements should be just the reverse of those which are instinctively made if standing on the ground. In the latter case, if one finds himself going over in one direction, the foot on that side is instinctively thrown out to that side; on a flying machine, if one wing is found to be depressed, the weight should be thrown to the opposite side in order to bring the wing down. This requires some practice to become second nature, but after awhile it is done semi-automatically, and without stopping to think.

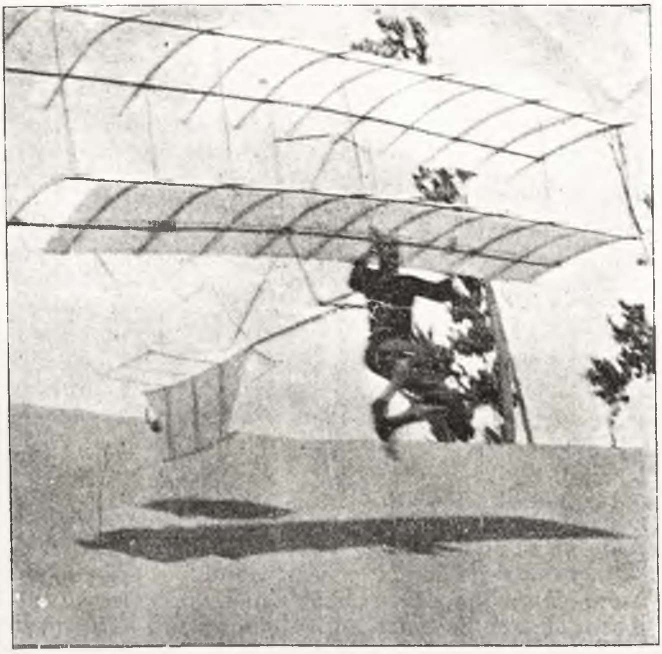

FIG. 239. Righted Again.

In Fig. 239 the machine has been righted up and is gliding forward on an even keel at a flatter angle of descent than the slope of the hill, so that the next picture shows increased height.

In Fig. 240 it is seen directly overhead of the camera and thoroughly under control, the legs having been raised up ready to be thrown in any direction to do the steering.

In Fig. 241 the trees have been passed for some distance, the apparatus is sailing steadily, and the ground is being gradually approached.

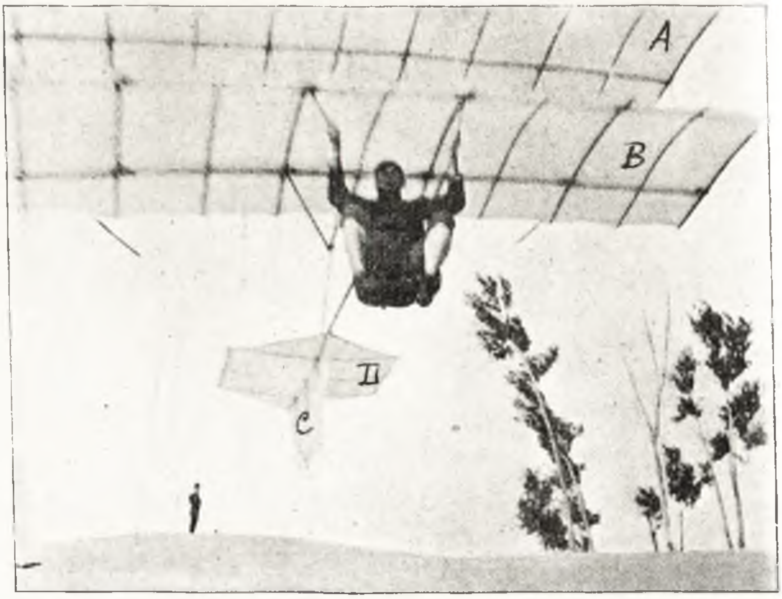

FIG. 240. Passing Overhead

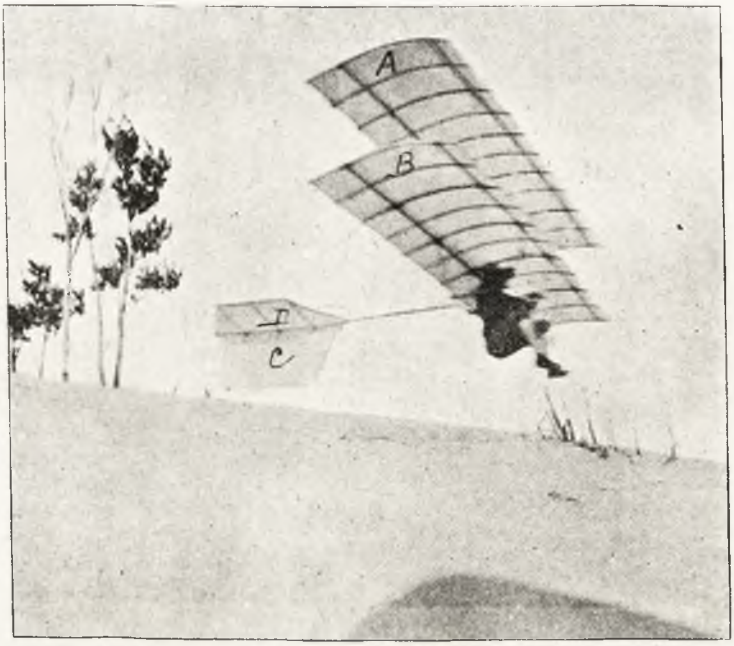

FIG. 241. Sailing Along.

In Fig. 242, the foot of the hill has been nearly reached, and it is time to think of alighting. This is very easily accomplished by pushing the weight of the body backward on the supporting bars, through a movement of the fore arms. The effect of this is to raise the front edge of the machine, thus increasing the angle of incidence and the consequent air pressure. This stops the speed, and as the diminished velocity also diminishes the pressure, the apparatus oscillates gently to a level keel, and the operator alights on the ground with almost no jar. The curi-

FIG. 242. Time to Think of Alighting.

ous in such matters will see this manœuvre performed thousands of times a day by the sparrows in the street. Mr. Herring and Mr. Avery, who were the experts who operated this machine at Dune Park, seldom or never struck the ground with greater force than would have been produced by jumping down one or two feet, and even when racing no sprained ankles occurred.

Fig. 243 shows the apparatus being carried back preparatory to making another glide. These were generally 200 or 300 feet long, and occupied 8 to 14 seconds, although it takes nearly 20 minutes to describe one of them. The sport is so exciting, the sensation of flying through the air is so delightful, that the operators immediately desire to make another glide, and they generally alternate in taking such flights. Each of the pictures shown has been taken from a different glide, but the effort has been made to have each represent a different phase, so that the sequence of aerial transit might be followed.

Mr. Chanute further said that the first requisite towards devising an artificial flying machine was to learn how such machines behaved in the air, and that he therefore advised constant practice to acquire the science of the birds. That the present auditors would doubtless like to know in greater detail just how it felt to be riding on the air, and he therefore begged to introduce Mr. Herring, who would describe the remainder of the pictures.

Mr. Herring stated that the slides previously described by Mr. Chanute were views of flights taken toward what was known as the valley or southwest side of the hill. But those from view 23 onward were from the lake side or northern slope. Fig. 243, he

FIG. 243. Going Back Again.

said, represented very well the method of carrying the machine in mild or moderate winds, for in toiling up the slope the operator's feet sank so deeply in the fine yellow sand that outside aid was sometimes sought from the wind pressure on the surfaces. This pressure, which was a lifting one, amounted in some cases to more than 100 pounds, but that there were drawbacks to its use which required considerable practice of the carrier to overcome. These drawbacks, he said, were first, those due to the varying direction at which the wind arrived—each variation producing very wide range of travel of the center of lifting effort, and, consequently, considerable leverages to contend with—leverages so great that the 25 pounds weight of machine often became almost a negligible factor beside the forces which had to be occasionally contended with unless great care and quickness of action were exercised to always point the front of the apparatus into the momentary direction of the wind; the accurate judging of the extent of these momentary changes was a matter in itself which required considerable practice.

Another difficulty of handling the machine on the steep slope was, he said, due to a property peculiar to arched surfaces, namely,

FIG. 244. Near the Starting Point.

to a strong propelling component which they possessed at small *positive*, as well as negative, angles of inclination (to the horizontal), *when held in a strongly ascending* current of air, such as always existed in winds at the hillside. This propelling component, which tended to force the carrier back down the hill *against the wind*, would frequently be brought about by gusts, or disturbances in the wind which affected the vertical trend and produced these propelling components so suddenly and with such force, in winds of 20 miles an hour or over, that it was generally safer to employ two men to carry what in a calm would be a comparatively light load for one.

After arriving at the starting point, which, he said, was not at top of the hill but just a few feet beyond the position shown in the Figure 244, the apparatus was held with the chord of the surfaces pointed downward at a considerable negative angle in order that the machine should sustain only its own weight, and at the same time the apparatus was directed squarely into the momentary wind so that both sides lifted equally, and, while the machine was thus poised, the operator (in front of the apparatus), released his hold and slipped quickly underneath, passing his arms over the longitudinal bars (called arm bars), beneath the lower surface, at the same time grasping the front pair of diagonal struts which joined these bars to the framing. This done, the whole machine was lowered until the small cross-piece in the rear of the operator rested on his hips or the small of his back. In this position a considerable leverage could be exerted, and with practice even a novice could soon hold the machine under perfect control until the actual start was made down the hill.

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Continuing, Mr. Herring said that in view of the small size of the machine, exposing in the present instance but 131 square feet of surface, one in first handling it would be surprised at the very great lifting effect, as well as the extent of the disturbing forces which come into play in comparatively light winds. He explained that this increased lifting effect was due to the very great superiority of arched surfaces over plane ones. This superiority had been first discovered and explained by the late Otto Lilienthal, a German engineer, who pointed out that the lifting forces which come into play were those due to a considerable thickness of air strata swinging around the arched profile of the surfaces—producing by their centrifugal moment (a partial vacuum on the upper or convex side of the surfaces and an added pressure on the lower or concave side—these together), giving lifting effects at small angles of inclination, such as from three to four degrees, (the same as used in flight on the present apparatus) equal to from eight to twelve times as much as could be produced by perfectly plane surfaces at the same angles and speed. It was common practice, Mr. Herring said, to designate all these machines as *aeroplanes*, although it was probable that if the inventor were limited to flat surfaces man-flight would not be possible with them, and, in view of the wide differences between the properties of plane and arched surfaces, Mr. Chanute and he used the word *aerocurve*, to designate the latter form. Continuing, the speaker said that on account of the internal irregularities which all winds possessed, it was a great deal more difficult to control any gliding machine on the ground than when the operator was in the air, and that this was especially true of the machines, that had been provided with the automatic regulating devices; on these, he said, the effect of the operator to keep the balance *proper*, while in flight, was, except in extreme cases, almost nil; but that when automatic regulation was absent or momentarily shut off, the flights, in winds of upwards of fifteen miles an hour, were marked by numerous movements of the operator requiring great quickness and considerable bodily strength which tired one almost as much as carrying the machine single handed up the hill. He said, to gather an idea of what those difficulties were which had to be contended with by either the operator or the mechanism, one might recall the actions of smoke issuing from a chimney which, if watched for any two succeeding fractions of a second, would show that its course was rarely the same, that in moderate or high winds it consisted of thousands of irregular curves and twists which came with a suddenness and irregularity greater than any man could intelligently follow, even mentally. He stated that their experiments had convinced them that similar disturbances existed throughout all winds, even the most steady, and that *as each of these changes or "gusts" had its disturbing effect on any apparatus depending for dynamic support on the air*, it was plain to be seen why Mr. Chanute had placed so much importance on the problem of securing automatic equilibrium, as the latter was, undoubtedly, by far the most important of all the many difficulties connected with the whole subject. Consequently, nearly all of their recent experimental work had been directed to a study of these "gusts," or wind changes, and especially to the counteraction of their disturbing effects by automatic machinery. *For both felt convinced that without ample provision for automatically overcoming at least the more dangerous of these gusts a practical aerocurve, or aeroplane flying machine would be out of the question.* Mr. Herring said he felt himself to be too much of an enthusiast to express his own opinion of what had been accomplished by these experiments, but would leave it to others to form their opinions of the results, which, he said, were substantially as follows: That, whereas the maximum (natural) wind velocity in which an unregulated machine was ever controlled by an operator (Lilienthal) was in the neighborhood of 22 miles an hour, they had been able to experiment on the machine here shown in winds of 31½ miles an hour, corresponding to wind *energy* of about three times as great, with entire safety, and with another apparatus and more complex regulator this limit had been raised very much higher. Also, notwithstanding the fact that neither Mr. Avery nor the speaker, who operated the machines, possessed anywhere near the skill exhibited by Lilienthal, the latter's best flights had, nevertheless, been equaled if not exceeded.

He said that before describing the succeeding views, he wished to explain that, though he had stated that the exertion required in keeping the balance proper of the present machines was almost nil, he did not wish to convey the impression that movements of the operator's weight were therefore not resorted to. On the contrary, they were very necessary in directing both the course and the angle of descent, and that extreme sensitiveness of the machine to these movements of the operator was an essential feature to secure success with this type of apparatus, and that the ability to gauge these movements, as well as the speed and angle of the machine on the other hand, were the main points of skill required of the operator. Returning again to the views, he stated that after the machine was poised, as previously explained, the front edges were brought down until the chord of these surfaces pointed downward nearly parallel with the slope of the hill. In this position a running start was made towards the wind; the operator meantime advanced himself on the arm bars until he reached the proper position for flight, and as the speed increased, the apparatus gradually carried more and more of the operator's weight until he was entirely sustained. From this point the machine carried him the balance of the flight through the air, at a speed, and an angle of descent, dependent almost wholly upon his position on the apparatus. This speed varied all the way from 10 to 40 miles an hour in reference to the ground, or from 18 to 57 miles per hour in reference to the air, at the will of the aviator. A perfect guide, the speaker said, to the speed of the machine in reference to the air was furnished to the

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operator, as well as to the spectators below, by the pitch of the note which the wires and framing made in passing through the air, a note similar to the shrieking of the shrouds of a ship in a storm.

The running start *in a calm* consisted of about half a dozen steps; *in moderate winds*, from two to three; and in *high winds* (those above 25 miles an hour), it was only necessary to give a slight positive inclination to the surfaces, when the machine and operator were raised high in the air, and then commenced their forward journey against the wind. The advance at a positive angle of inclination was due to the fact that arched surfaces possessed a strong propelling component, even at small *positive* inclinations (to the horizontal) *in strongly ascending* currents such as always existed on the windward slope of the hill. After reaching a certain point over the hillside (approximately one-third the way down the hill), a sudden decrease in support was generally experienced, due, in all probability, to a mass of slower moving air between the base and top of the hill, as measurement with the anemometer showed very much higher wind at the starting point and at the foot of the hill (or over the level stretch below) than between the two. The relationship in a 23-mile wind having been found to be as follows: Velocity at the lake, 20 miles per hour; at the foot of the hill (distant 300 feet), 16 miles; from first third to middle of the hill 9 miles per hour; starting point (one-third from top), 23 miles; and top, 23½ miles per hour. From which it would be seen that from starting in a wind of somewhat higher velocity than that necessary for support (21½ to 22 miles per hour), the machine (in the space of from one to one and a half seconds) passed into a wind capable of exerting but little more than one-sixth of that effect; the equilibrium, however,

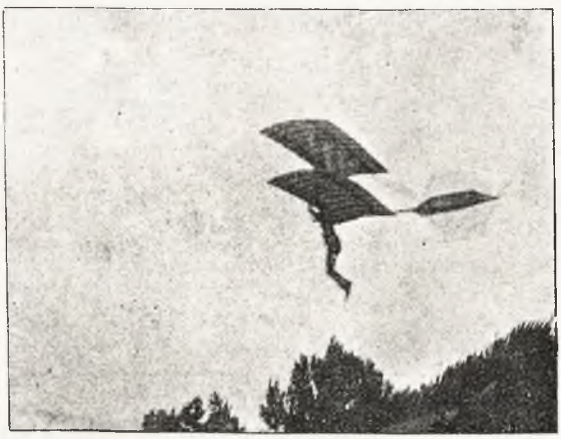

FIG. 245. Two Seconds After Start.

remained practically undisturbed; but to prevent losing headway, he said the operator should, in such a case, move his weight slightly to bring the surfaces at a greater negative angle than would be produced automatically by the regulating mechanism, as shown in Fig. 245, so that gravity might add to the speed during the descent and thus store a large part of the energy of the fall. After reaching the lowest point of this descent, which he said in some cases seemed to be attributable to a current of air curling backward against the mean wind, the operator again shifted his weight (or if he remained quiet the freshening wind would perform the same function through the regulating mechanism, but less quickly) and give the surfaces a slight positive angle as shown in Fig. 246, when by reason of the

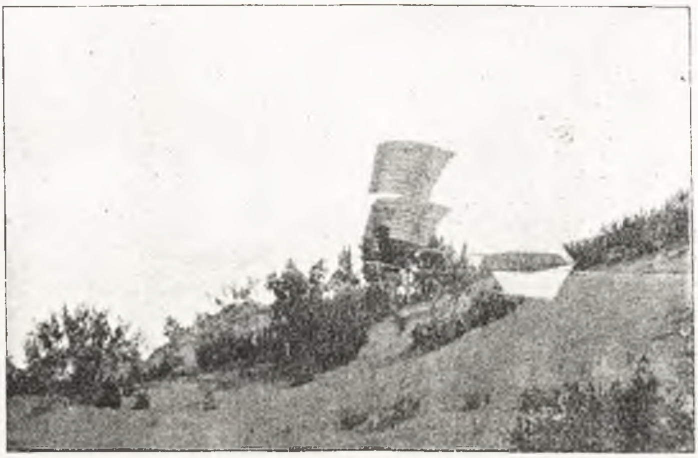

FIG. 246. Four Seconds After Start.

increased speed of the machine and the fresher wind over the level stretch of the beach, the apparatus immediately rose, sometimes with greater rapidity than it fell, to almost the same level from which the descent was started, as shown in Fig. 247, the whole operation between Figs. 245 and 247 rarely occupying as much as three seconds. After passing the position shown in the last named figure, the flight as a whole was steady along a gradually descending line of one in six to one in seven, and occasionally but rarely one in eight. In strong winds, however, he continued, the gusts in the wind made considerable undulations in the flight, on a number of occasions raising the machine and operator as much as forty feet above the starting point, and giving the remainder of the course a number of vertical undulations departing from eight to fifteen feet from the mean line of the flights. The sensations produced by these sudden variations being somewhat similar to that experienced in a quick starting

FIG. 247. Five Seconds After Start.

elevator. One great peculiarity, he said, which distinguished the sensation of riding on the air from all other modes of locomotion was the exceeding smoothness and elasticity of the support, *and although ascending or descending motions were occasionally imparted to the machine, which were practically equal to what gravity would produce on a free moving body in the same time, yet, the application of these forces was always so elastic that there was never the slightest shock felt.*

FIG. 248. Nearly Down.

Continuing, he said the line of flight eventually approached nearer and nearer to the sand when it became necessary to select a proper landing point, and, at the same time, to head the machine directly into the wind, as was being done in Fig. 248, the landing in which case would be effected some sixty or seventy feet nearer the camera than the piece of charred wreckage in the foreground;the length of flight being on an average 268 feet horizontally in a descent of 42 feet in windy weather, or 254 feet in a calm from the same point, thus showing that in flights against the wind the ascending trend of the latter (blowing from the lake over the hill) furnished but little more energy than that necessary to overcome its own horizontal component and that the length of flight measured on the ground, in gliding against the wind, was

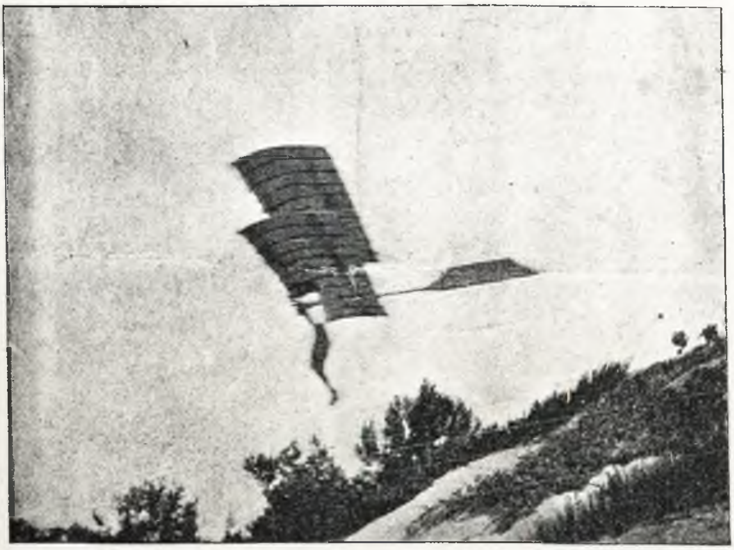

FIG. 249. Quartering.

more dependent upon the height from which the flight started than on the velocity of the wind.

Continuing, Mr. Herring said that so much had formerly been said relative to the necessity of starting and stopping against the wind that the impression had gone abroad that flight in any other direction with the present machines was impossible. He wished, therefore, to call attention to the Figs. 249, 250 and 251, which represented the machine facing north but advancing west of northwest in a wind coming from the northeast. These flights were known as 'quartering, in that they were made at an angle or "quartering" with the wind in order to make use of the ascending current over the slope which furnished in these flights *both support*

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Fig. 250. Quartering Flight Overhead.

and propulsion. Such flights, he said, in a sufficiently strong wind, could, in a suitable locality, having a long hillside entirely free of obstructions, be prolonged indefinitely, but that his best attempt in this direction lasted only about 48 seconds. This, he said, was accomplished with a similar machine with three superimposed surfaces in covering a distance of 927 feet. There were, however, he said, few localities among the lakeside sand hills where this length of flight might be made except at the risk of running into trees or other obstructions, so that no matter how much longer than the average the level part of any particular flight might be there was still the same operation (that shown in Fig. 252) to be gone through with at the end, namely, the winding up of gravity's spring by man-power. This, said Mr. Herring, was a part of the operation which made one think more of adding the motor than any other. Whether the time were ripe for this step or not could, perhaps, be best judged by others; his individual opinion was, however, in the affirmative, and that, judging from the action of power-driven models of the gliding machine, which he had recently built and tested, it was probable, he said, that the power machinery would add to, rather than diminish the stability of the glider, and if this conclusion proved correct, the

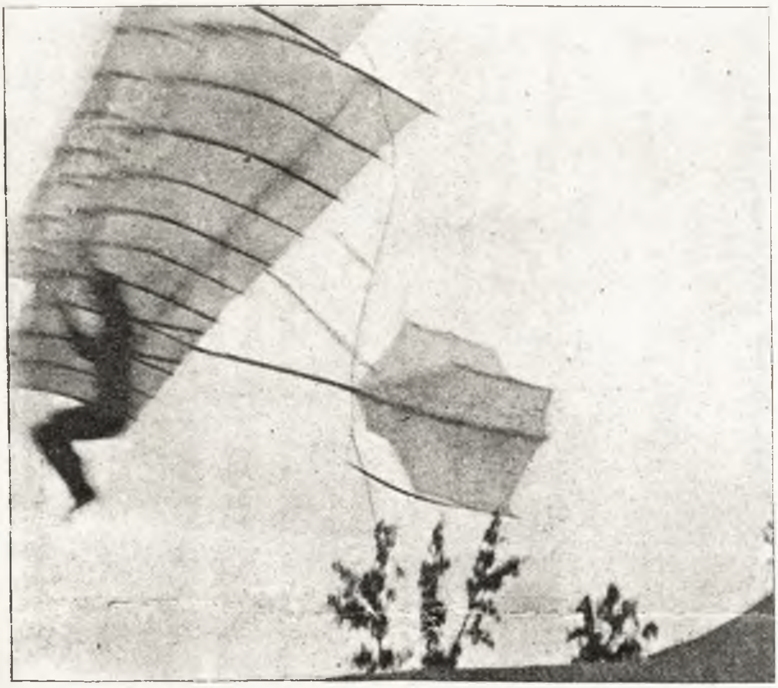


FIG. 251. Turning in Quartering Flight.

FIG. 252. Winding Up Gravity Spring.

finest mode of travel in the world, he thought, for the few, if not for the many, would not only be a possibility but a reasonable certainty of the near future.

President Johnston: I am sure we have all listened with a great deal of interest to Mr. Chanute's very interesting address and Mr. Herring's remarks, and if there are any others who have anything to say on this subject we will be glad to hear from them.

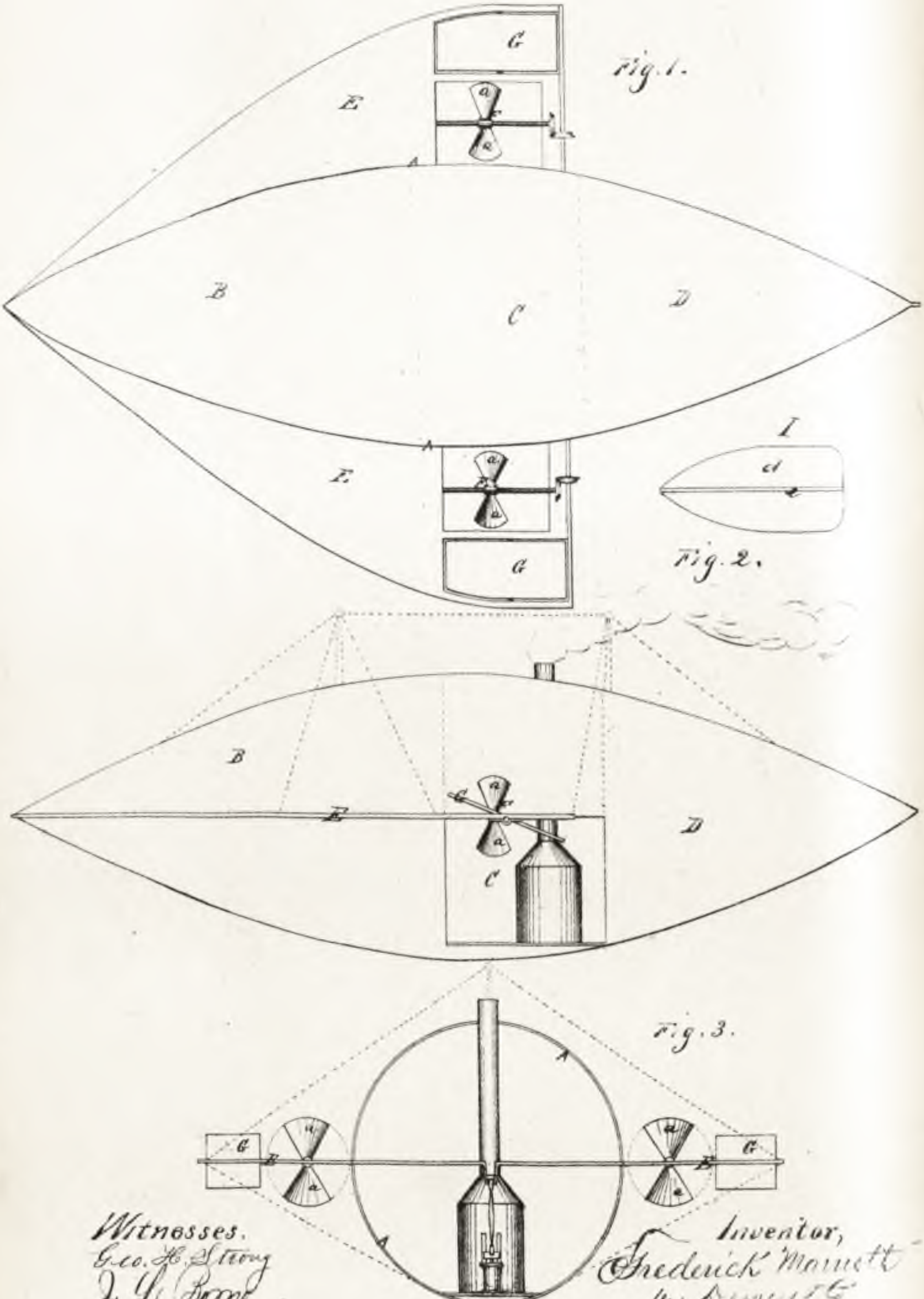
Mr. L. L. Summers: I would like to call attention to the fact that Mr. Chanute's modesty has prevented his calling attention to the particular work he has done. It is well known that Mr. Maxim, in England, has spent a small fortune in perfecting his machine, and his effort has been towards constructing a machine of full size, and I believe some $40,000 or $50,000 has been spent on it. He has never succeeded in actually flying, and he has broken his machine several times in getting away from the tracks. Mr. Chanute has endeavored in every way to avoid dangerous experiments and has confined his experiments to solving the problem of equilibrium. He has devoted a number of years to the subject, and I think all those who have read his book and know the great care he has taken to point out the success and failures of others, feel indebted to him. I think it is a source of congratulation to the West that we have an engineer and a scientist who is willing to devote himself to the subject in the way he has, and along the line he is working unquestionably must come our ultimate success. Many fail to appreciate that equilibrium must first be obtained before we can hope to accomplish successful flight, and to this problem Mr. Chanute's whole attention has been turned.

CERTIFICATE NOT PRINTED

No. 97,100. PATENTED NOV. 23, 1869.

F. MARRIOTT.

AERIAL STEAM CAR.



Witnesses.
Geo. H. Strong
J. L. Boone

Inventor,
Frederick Marriott
by Dewey & Co
his Attys

United States Patent Office.

FREDERICK MARRIOTT, OF SAN FRANCISCO, CALIFORNIA.

Letters Patent No. 97,100, dated November 23, 1869.

IMPROVEMENT IN AERIAL STEAM-CARS.

The Schedule referred to in these Letters Patent and making part of the same.

To all whom it may concern:

Be it known that I, FREDERICK MARRIOTT, of the city and county of San Francisco, State of California, have invented an Aerial Steam-Carriage; and I do hereby declare the following description and accompanying drawings are sufficient to enable any person skilled in the art or science to which it most nearly appertains, to make and use my said invention or improvements without further invention or experiment.

My invention relates to a steam-carriage or vessel, which is so constructed that it can be moved or propelled through the air by mechanical means, and which can be steered in its course with the same facility that a vessel floating upon the surface of a body of water obeys the movements of her rudder.

My vessel or carriage is constructed of any light and strong material, and is made pointed at both ends, or cigar shaped, each end being inflated with hydrogen or other gas.

Extending from the forward point of the carriage to about the middle of the vessel, and on each side, is a vane or wing, which gradually widens as it extends toward the rear.

These wings serve to carry the carriage steadily through the air.

The carriage is caused to move through the air by screw or other propellers, which are driven by a steam or other power-engine of suitable size and capacity.

In the rear end of each of the vanes or wings, at the sides of the vessel, is attached a plane, which turns upon an axle, and by which any desired elevation can be given to the vessel.

A tail or rudder is also attached to the rear pointed end, by means of which any required direction can be given to the vessel when it is in motion.

In order to more fully illustrate and describe my invention, reference is had to the accompanying drawings, forming a part of this specification.

Figure 1 is a top view of my aerial carriage or machine.

Figure 2 is an elevation of one side.

Figure 3 is a transverse vertical section through the centre.

A represents a frame or structure, in the form of two cones united at their bases, and made of some light and strong material.

This structure is divided into three compartments, B, C, and D, the compartment C being in the middle of the vessel, inside of which the engine is carried.

The compartments or gasometers B and D are covered with some suitable fabric, for containing hydrogen, or other gas specifically lighter than atmospheric air, with which the compartments are to be filled, for which purpose any of the prepared fabrics capable of retaining gas, such as is employed in the manufacture of balloons, will answer.

Beginning at the point of the vessel, and extending about half way its length toward the rear, are wings or planes E E, one on each side.

These wings are rigidly fixed to the side of the car, so as to lie horizontally in a plane with its centre, and gradually increase in width toward the rear.

These wings aid in buoying up the car, and keeping it steady in its movements through the air.

Opposite the centre of the vessel, and operating in suitable openings in the rear end of the wings E E, are propellers F F.

These propellers consist of two blades, *a a*, bent to the proper curvature, and driven by an engine of the proper capacity, carried in the apartment C.

The kind of power or style of engine employed is immaterial, the only requisite being that it shall be as light as possible, and, when steam is used, that the boiler shall have a sufficient amount of fire-surface to enable the generation of steam to be carried on as fast as possible.

The propellers F, working, as they do, outside of the body of the car, and through the horizontal wings, have full grasp upon the air, to carry forward the car.

Turning upon an axle, through openings in the wings, outside of the propellers, are what I call "planes," designated by the letters G.

These planes vibrate upon axles placed transversely to the longitudinal axis of the car, and are operated, by suitable mechanism, from the interior of the compartment C, by the engineer.

By turning these planes to the proper angles, the elevation of the car can be regulated.

This is one of the principal features of the invention, as, by their use, the vessel can, at all times, be controlled, and its elevation regulated, with the same ease that a bird gives itself an upward or downward direction with its wings.

The tail or rudder I is composed of two parts, *d* and *e*, placed at right angles to each other, their planes intersecting through the middle of each, thus forming a vertical and a horizontal rudder.

This tail or rudder is attached to the rear end of the cigar-shaped frame A, by means of a hinge or other joint, so that it can be turned to stand at any desired angle to the frame, either up or down, and thus give the engineer a more complete control over the movements of the vessel.

The entire machinery is operated from the central compartment or cabin C by suitable mechanism.

This flying boat or vessel, I call "The Avitor," its governing principle and general arrangement being similar to that of a bird moving through the air.

The Avitor, when fully inflated, does not contain sufficient gas to cause it to rise, but remains in its position until the propellers are started into operation, and begin to beat the atmosphere, when it rises with the greatest ease, being driven forward, at the same time, through the air.

What I claim as my invention and improvement in aerial or flying-machines, is—

1. A spindle, having conical ends B and D, and a space, C, in the middle, between the conical ends, for the motive-power, attendants, passengers, and freight.

2. The rigid or stationary wings or planes E, arranged upon the sides of the spindle of an aerial or flying machine, for the purpose set forth, substantially as described.

3. And, in combination with the rigid or stationary wings or planes E, on the sides of a flying machine, the adjustable plane G, arranged to operate substantially as described.

4. In combination with a flying machine, a four-vaned rudder or tail, I, arranged to vibrate in either direction, substantially as described, for the purpose of steering the machine.

5. And, in combination with the four-vaned rudder or tail I, the adjustable planes G, arranged to co-operate with the rudder, when required to steer the machine.

In witness whereof, I have hereunto set my hand and seal.

FREDERICK MARRIOTT. [L. S.]

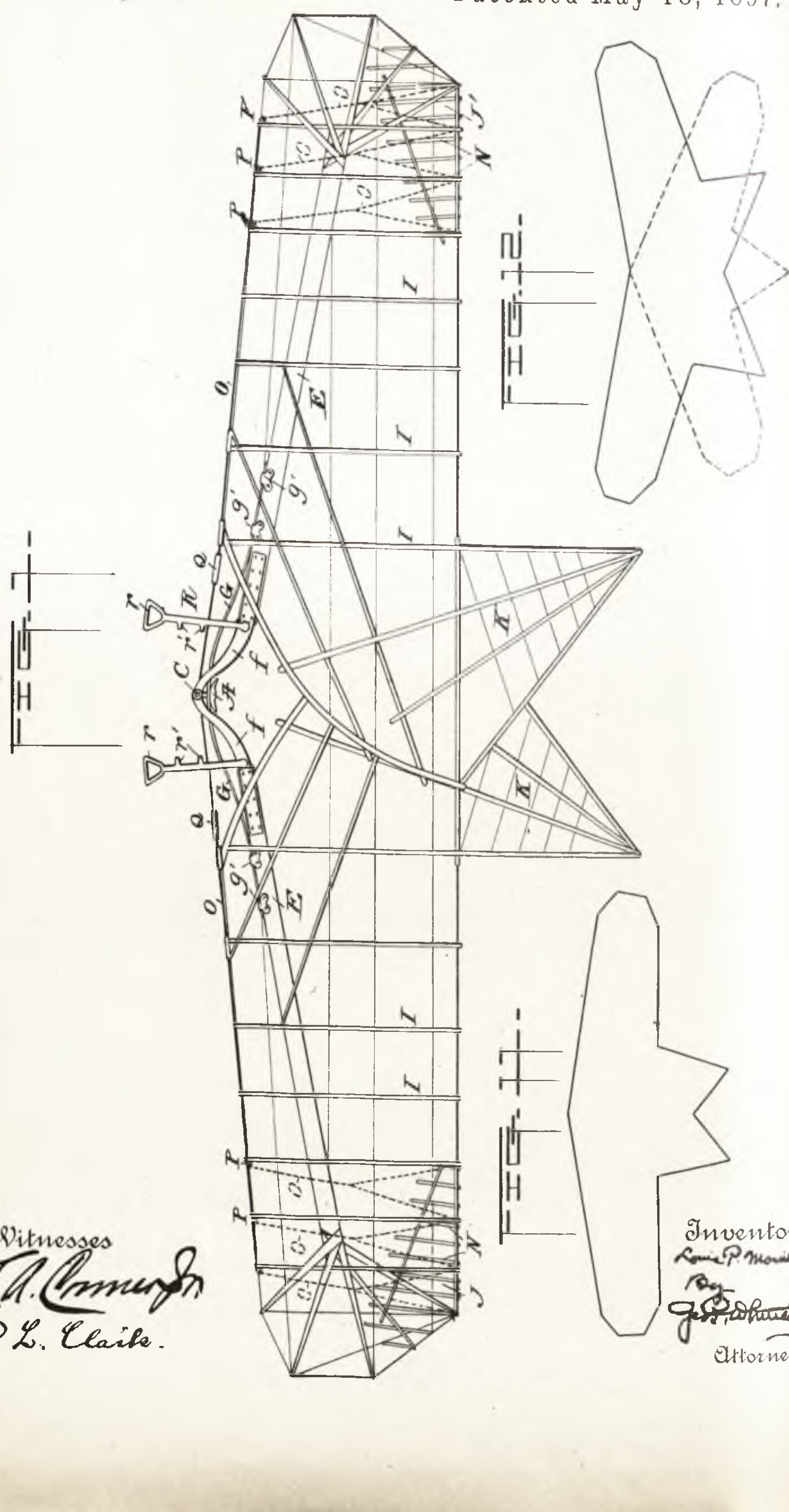
Witnesses:
A. SMITH,
GEO. H. STRONG.

CERTIFICATE NOT PRINTED

(No Model.) 4 Sheets—Sheet 1.

L. P. MOUILLARD.
MEANS FOR AERIAL FLIGHT.

No. 582,757. Patented May 18, 1897.



Witnesses
L. A. Connor Jr.
P. L. Clark.

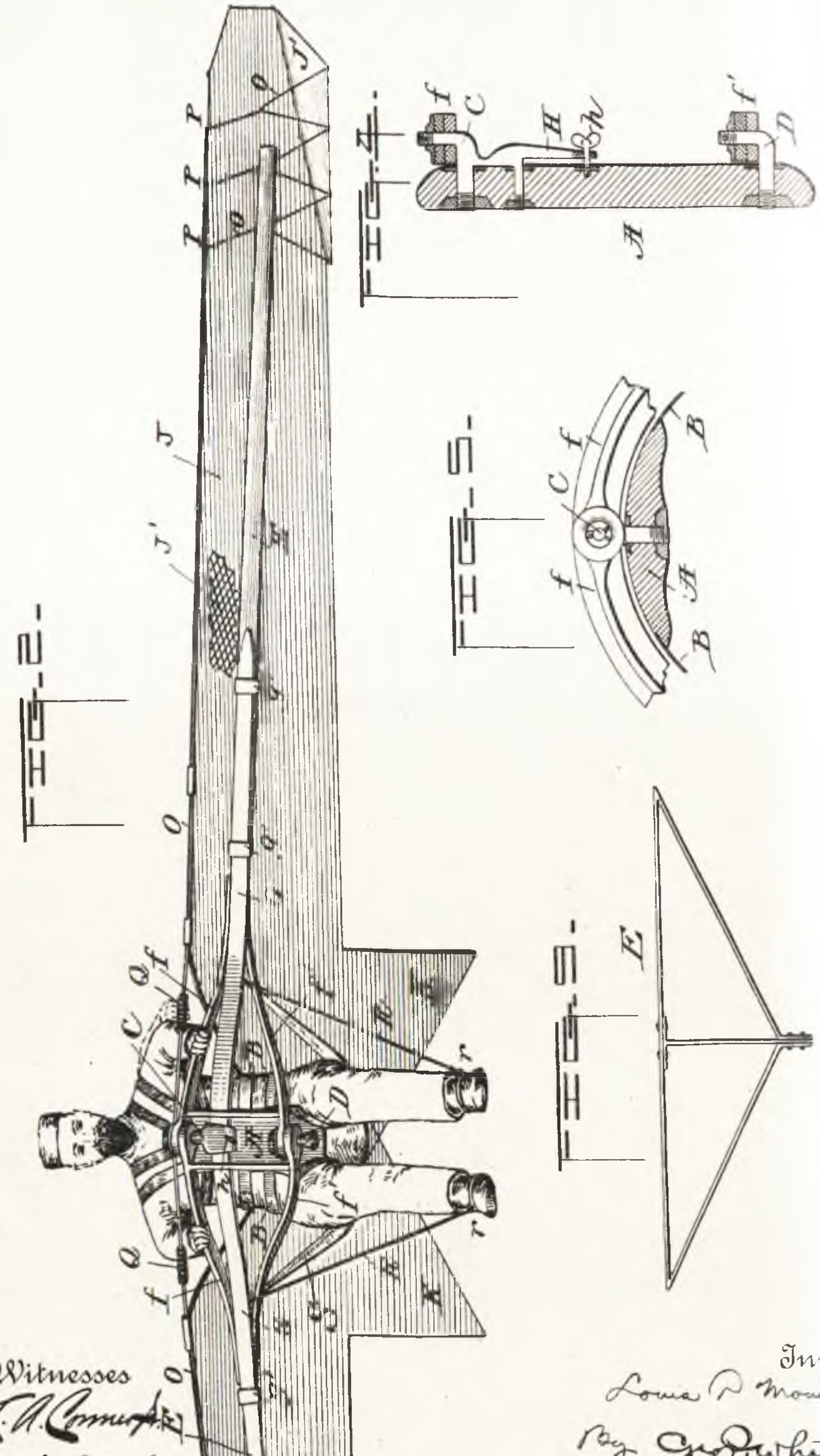
Inventor
Louis P. Mouillard
By
Geo. P. Whittlesey
Attorney

(No Model.) 4 Sheets—Sheet 2.

L. P. MOUILLARD.

MEANS FOR AERIAL FLIGHT.

No. 582,757 Patented May 18, 1897.



Witnesses
L. A. Connor Jr.
P. L. Clark

Inventor
Louis P. Mouillard,
By Geo. P. Whittlesey
Attorney

— M. don't say one flap pulled down more than other create dif. resistances.

— Does not teach unequal angles.

— Merely ~~thought~~ had steering plan by pulling down one flap or other as wanted to turn, not knowing would slew mach. round & cause fall.

— Judge Hand speaks of this.

— M. never tried.

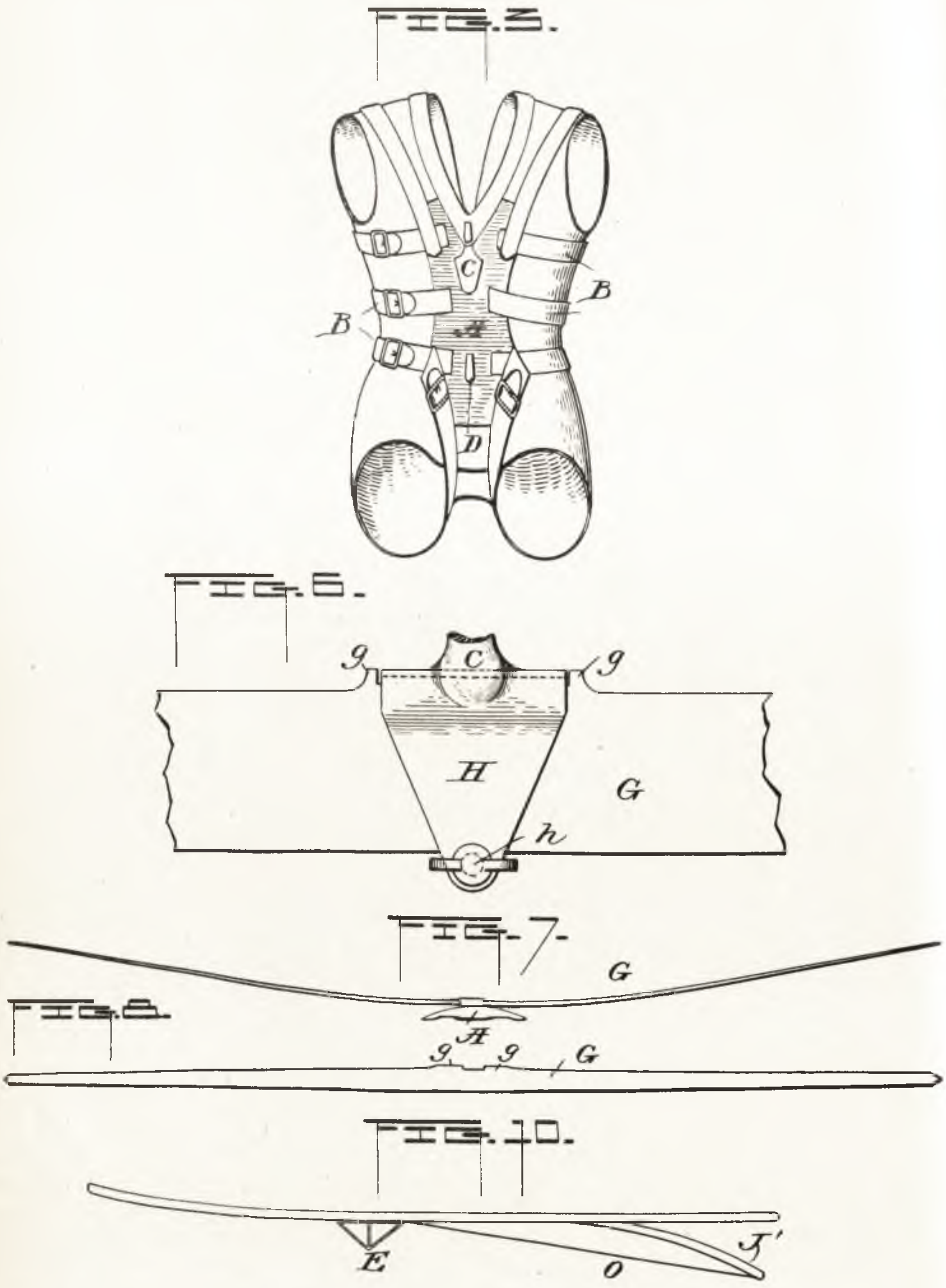
(No Model.)

4 Sheets—Sheet 3.

L. P. MOUILLARD.

MEANS FOR AERIAL FLIGHT.

No. 582,757. Patented May 18, 1897.



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Attorney

(No Model.)

4 Sheets—Sheet 4.

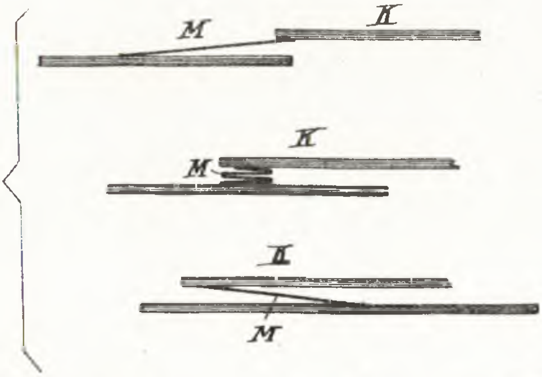
L. P. MOUILLARD.

MEANS FOR AERIAL FLIGHT.

No. 582,757

Patented May 18, 1897.

FIG. 13.



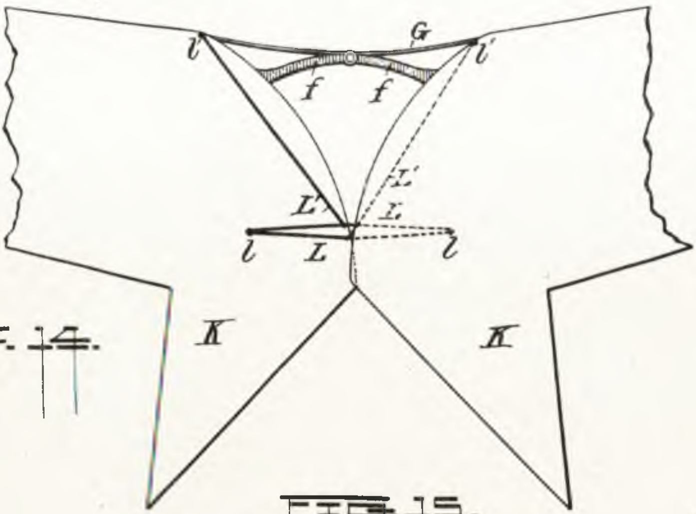
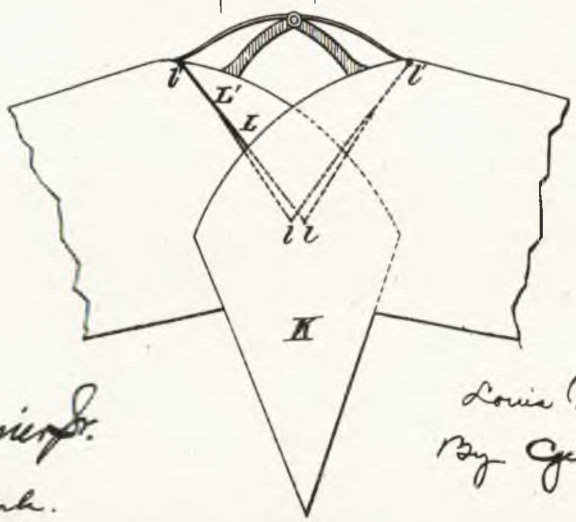


FIG. 14.

FIG. 15.



Witnesses
L. A. Cornier Jr.
P. L. Clark.

Inventor
Louis P. Mouillard
By Geo. W. Whitney
Attorney

UNITED STATES PATENT OFFICE.

LOUIS PIERRE MOUILLARD, OF CAIRO, EGYPT, ASSIGNOR OF ONE-HALF TO OCTAVE CHANUTE, OF CHICAGO, ILLINOIS.

MEANS FOR AERIAL FLIGHT.

SPECIFICATION forming part of Letters Patent No. 582,757, dated May 18, 1897.

Application filed September 24, 1892. Serial No. 446,786. (No model.)

To all whom it may concern:

Be it known that I, LOUIS PIERRE MOUILLARD, a citizen of the Republic of France, residing at Cairo, Egypt, have invented certain new and useful Improvements in Means for Aerial Flight; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters and figures of reference marked thereon, which form a part of this specification.

My invention relates to a machine for navigating the air by the force of the wind, and has for its object the imitation of the soaring of large birds, which I have been watching for thirty years in tropical latitudes. I know from abundant personal observation that such birds can, without a single flap of their wings, float up into the air on a sufficient wind, sail about at pleasure, circle and rise to great altitudes, glide down in any direction, and come back to their original starting-point upon fixed rigid wings, solely by the skilful use of the power of the wind. This I propose to imitate.

It is well known that if a plane surface, or one slightly concave, be exposed to the wind at an acute angle the resulting wind-pressure will affect it in two directions. One is a vertical reaction, which lifts it up, and the other reaction either drifts it back or drives it forward, according as the surface be inclined, either above or below the horizon. It is also known that as the angle which the current of air makes with the surface is changed there is a corresponding change in the position of the center of pressure on the surface. In order to utilize these forces derived from the wind, three essential requisites may be observed: first, equilibrium must be maintained under all conditions of angle of incidence and speed of translation; second, the angle of incidence with the wind must be changed in order that the apparatus may rise or descend; third, the apparatus must be susceptible of direction horizontally, so that it may go to the right or left, or, in other words, be steered.

My invention consists in certain novel features of construction and combination of parts for the purpose of complying with these essential requisites and of imitating in a simple way the principal maneuvers performed by soaring birds. It comprises an aero plane or planes or concave surfaces provided with devices for firmly attaching it or them to the body of the aviator and arranged to permit movement of the plane or planes in a horizontal direction only with reference to the body of the aviator. The apparatus is thus essentially different from those in which a flapping or vertical motion is imparted to the wings. I rely entirely upon the wind-pressure to sustain my apparatus and not upon any downward thrust upon the air, either by flapping wings or revolving propeller-wheels.

The horizontal movements of my aero plane or planes or concave surfaces are solely for the purpose of changing the relative position of the load or center of gravity in order to cause the apparatus to rise or descend. When the planes are thrust forward, the load is relatively farther back and the aerodrome rises. When the planes are pulled back to the rear, the load is farther to the front and the apparatus glides downward.

Reference is to be had to the accompanying drawings, forming a part of this specification, in which similar letters of reference indicate the same parts in all the figures.

Figure 1 is a plan of the apparatus. Fig. 2 is a front elevation showing the operator in position. Fig. 3 is the cuirass or corset which attaches the wings to the body of the operator. Fig. 4 is a vertical section of the breastplate of the cuirass or corset. Fig. 5 is a horizontal section thereof. Fig. 6 is a front elevation of the spring-clamp. Figs. 7 and 8 are plan and front views of the spring. Fig. 9 is a section of a main beam. Fig. 10 is a transverse section of a wing, showing the horizontal steering devices. Figs. 11 and 12 show the various positions taken by the wings. Fig. 13 shows the various positions of the stop-cords. Figs. 14 and 15 show the arrangement for closing the tail portions.

The apparatus comprises, first, a cuirass or corset composed of a rigid breastplate A, provided with strong straps B or a close-fitting garment, or both, for firmly fastening it to the body of the aviator. The breastplate is specially made to fit each operator, being preferably composed of wood. It provides the operator with an artificial sternum, an organ largely developed in the bird, but practically lacking in man.

The wings, which constitute the aerial plane of the apparatus, are hinged to the breastplate, each on a vertical axis, so as to be capable of movement forward and backward only. It is preferred to hinge them upon the hooks C D, which are rigidly attached to the breastplate, one above the other. The wings consist, essentially, of a light but strong framework covered with silk or some other suitable material. The main beams E of the wings may be of bamboo or of metal tubing, but I prefer to construct them as hollow-plate girders of aluminium. To their inner ends are riveted the curved metallic arms, having eyes $f f'$, which fit on the hooks C D, respectively. The tips of the wings are normally thrown forward in advance of the axis on which they are hinged by means of a strong spring. This may be of any suitable construction and may be attached in any suitable manner, but it is preferred to use a flat steel spring G, the middle of which is firmly clamped between a plate H and the breastplate by a thumb-screw h, giving the requisite pressure. The spring may have lugs g to fit against the edges of the plates and prevent endwise movement of the spring. The ends of the spring are fastened to the beams E, as by slips g'. The spring does not have a great range of movement, and can therefore be made very strong. Normally it curves forward in order to throw the wings into the position shown in Fig. 11, which is their disposition when at rest. Fastened rigidly to the main beams E are crossbars I, preferably pieces of bamboo. Under the frame of the wings is tightly stretched a light net of silk twist J' with meshes about two inches square. Under this is spread a covering of silk or other fabric J, which is attached to the net at a sufficient number of points to fasten it thoroughly.

I do not, however, wish to confine myself to any particular mode of constructing the framework. It may be built of any suitable material and in any suitable manner. I may even duplicate the planes, placing one above the other and connecting them by braces or trusses to secure vertical stiffness.

The wings are preferably long and narrow, and they are preferably provided at their inner rear ends with rearwardly-projecting triangular portions K, which together constitute a tail. This, however, is not intended for steering, but merely to permit the effective surface of the aeroplane to be varied by closing one tailpiece over the other. In order to accomplish this without danger of rubbing or fouling, one wing is set higher than the other, but in approximately a parallel plane therewith. A difference of four inches between the planes is sufficient.

To positively effect the closing of the tail, the wings may be pulled back by hand, but it is preferred to arrange also some means by which the movement can be given by the feet of the operator. The arrangement illustrated is as follows: At the points 1 1 on the wings are fastened two cords L L. To the middle of each cord is attached a cord L', which runs through an eye 1' near the front of the wing and thence to a stirrup 12. A pull on the cord L' carries the middle of the cord L toward the eye 1' and causes the wings to swing back one over the other, as shown in Fig. 15, the cords lying in the space between the wings. Other modes of accomplishing this will be readily devised, and I do not intend to confine myself to the one shown and described.

To limit the movement of the wings, stop-cords M are attached to the wings.

In order to provide for the horizontal steering of the apparatus—that is, the guiding it to the right or left—I substitute for the ordinary rudder a novel and more effective arrangement. A portion J' of the fabric at the rear of each wing is free from the frame at its outer edge and at the sides. It is stiffened with suitable blades or slats N, of flexible material, and normally rests up against the netting. Cords O are attached to the rear edge of the portion J' and pass forward to rings P, where they unite and run to the handles Q near the inner ends of the wings. A pull upon one of these handles causes the portion J' to curve downward, as shown in Fig. 10, and thus catch the air, increasing the resistance upon that side of the apparatus and causing it to turn in that direction. Any other equivalent device for creating at will an additional resistance to the air on either side of the apparatus may be employed, and I do not limit myself to the one shown and described.

The forward movement of the wings is usually produced by the arms of the aviator, but in case of emergency the feet may be used, operating upon the rods R, fastened to the main beams and provided with stirrups r and foot-rests r'.

A strap S is fastened to the beams E to afford a seat for the aviator.

Upon preparing to start the aviator stands upright, carrying the apparatus by the broad shoulder-straps of the cuirass. The aeroplane can glide upon the air in two ways only—viz., by a fall from a height sufficient to procure a speed which shall cause the air to support the apparatus or by a skilful utilization of the force of the wind, which must blow at least ten miles an hour to enable the aeroplane to operate. This wind-pressure and the force of gravity provide for translation in any direction, and this constitutes the great economy of soaring flight.

The life of the aviator depends upon the spring, which should be of sufficient strength to hold the two wings with their front edges on a straight line at a speed of twenty-two miles an hour. At a higher speed the increased pressure upon the wings, produced by the forward motion through the air, throws them backward, and the center of gravity thus being moved relatively forward the wings tend to assume a more horizontal position and thus compensate for the otherwise increased vertical reaction of the air-pressure. Should the speed diminish, the spring pulls the wings forward, opening the tail portion and tilting the wings upward, so that they present a greater angle to the air and thus increase the lifting power of the pressure.

A well-proportioned spring will produce, automatically, most of the changes in the horizontal angle which the wings make with each other in order to maintain the vertical equilibrium and level flight of the apparatus under varying speeds. It is necessary, however, to frequently regulate the position of the wings with the hands or feet. When the tips of the wings are pulled back, a forward movement or a downward plunge results. To counteract too violent a movement of this sort, the wings must be thrown forward.

Should the spring break, the wings must be pulled forward vigorously to prevent a sudden headlong plunge, and the aviator should therefore be strong enough to operate the wings in case the spring fails. It is therefore possible to dispense with the spring and depend entirely upon the strength of the operator to hold the wings in their proper position; but this is not recommended.

From the foregoing statements it will be seen that vertical steering or equilibrium depends upon the forward and backward movement of the wings, whereby the center of gravity is carried, respectively, backward and forward. The horizontal steering is effected by the downwardly-movable rear portion J′ of the fabric in the manner already described. When both sides are pulled down together, they serve as an effective brake to check the speed. The amount of surface of the wings should be varied in proportion to the weight to be carried and in accordance with the speed of the wind by which it is proposed to sail. The apparatus here shown is designed to furnish, when the wings are fully open, a surface of about one square foot to the pound of total weight, (including both aviator and apparatus,) this being about in the proportion of most soaring birds. The apparatus is intended to sail with winds varying between ten and twenty-five miles per hour.

The weight of the apparatus will vary, of course, with the substance used in its construction, but the one shown and described should not exceed fifty-five pounds, and may possibly be reduced below that figure.

This apparatus is intended as elementary rather than to indicate the best that may be accomplished. The surfaces and proportions may be departed from, but the description and illustration are regarded as closely setting forth a new type of aerodrome.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. A soaring-machine consisting of an aeroplane composed of two wings, each hinged upon a vertical axis and capable of forward and backward movement only, substantially as described.

2. A soaring-machine consisting of two wings, each hinged upon a vertical axis, an automatic regulating device controlling the angular position of the wings with the variation in speed, substantially as described.

3. A soaring-machine consisting of two wings, each hinged upon a vertical axis, and a mechanical device attached to said wings for throwing forward the tips of the wings, substantially as described.

4. A soaring-machine consisting of two wings, each hinged upon a vertical axis, and a spring attached to said wings, substantially as described.

5. A soaring-machine consisting of two wings, each hinged upon a vertical axis, and a spring normally holding the tips of the wings in advance of said axis, substantially as described.

6. A soaring-machine consisting of two wings, each hinged upon a vertical axis but in different approximately parallel planes, so that one can close partly over the other, substantially as described.

7. A soaring-machine consisting of two wings, each hinged upon a vertical axis, and each having a tail portion adapted to close one over the other, substantially as described.

8. A soaring-machine consisting of two wings, each hinged upon a vertical axis, and adapted to close one over the other, and a mechanical device attached to said wings for positively closing them at will, substantially as described.

9. A soaring-machine consisting of two wings, each hinged upon a vertical axis, and a cord attached to each wing and running through an eye in the other wing, for closing said wings together substantially as described.

10. A soaring-machine consisting of two wings, each hinged upon a vertical axis, and provided with stop-cords to limit their angular movement, substantially as described.

11. A soaring-machine consisting of two wings, each hinged upon a vertical axis, and having a portion movable out of the plane of the wing, substantially as described.

12. A soaring-machine having wings adapted to move in horizontal planes, a portion of the fabric covering each wing being stiffened by flexible slats and having its rear edge free from the frame of the wing, and cords attached to said rear edge for pulling it downward, substantially as described.

13. A soaring-machine consisting of two wings, each composed of a framework, a net spread under the framework, and a covering of fabric fastened below the net, substantially as described.

14. A soaring-machine consisting of an artificial sternum adapted to be fastened to the body of the aviator and two wings, hinged to said sternum on an upright axis, substantially as described.

15. A cuirass or corset for an aviator consisting of a rigid breastplate provided with means for firmly attaching it to the body, and having attachments for receiving and supporting an aeroplane, substantially as described.

16. A cuirass or corset for an aviator, consisting of a rigid breastplate provided with means for firmly attaching it to the body, and having hooks upon which a pair of wings may be hinged on a vertical axis, substantially as described.

17. The combination with the cuirass having a rigid breastplate A, of the hooks C, D, one above the other, and a clamp, as H, adapted to hold a spring, as G, substantially as described.

18. The combination with the rigid breastplate A carrying the hooks C, D of the wings, each having arms F provided with eyes $f f'$ to fit on the hooks, substantially as described.

19. The combination with the rigid breastplate A having the hooks C, D and the clamp H, of the wings each having arms F hinged upon the hooks, and the flat steel spring G held at its middle by the clamp, and having its ends attached to the wings, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

LOUIS PIERRE MOUILLARD.

Witnesses:

S. NURIPOY,

C. P. LUGOLD.

(No Model.)

2 Sheets—Sheet 1.

T. M. CREPAR.

AIR SHIP.

No. 588,556.

Patented Aug. 24, 1897.

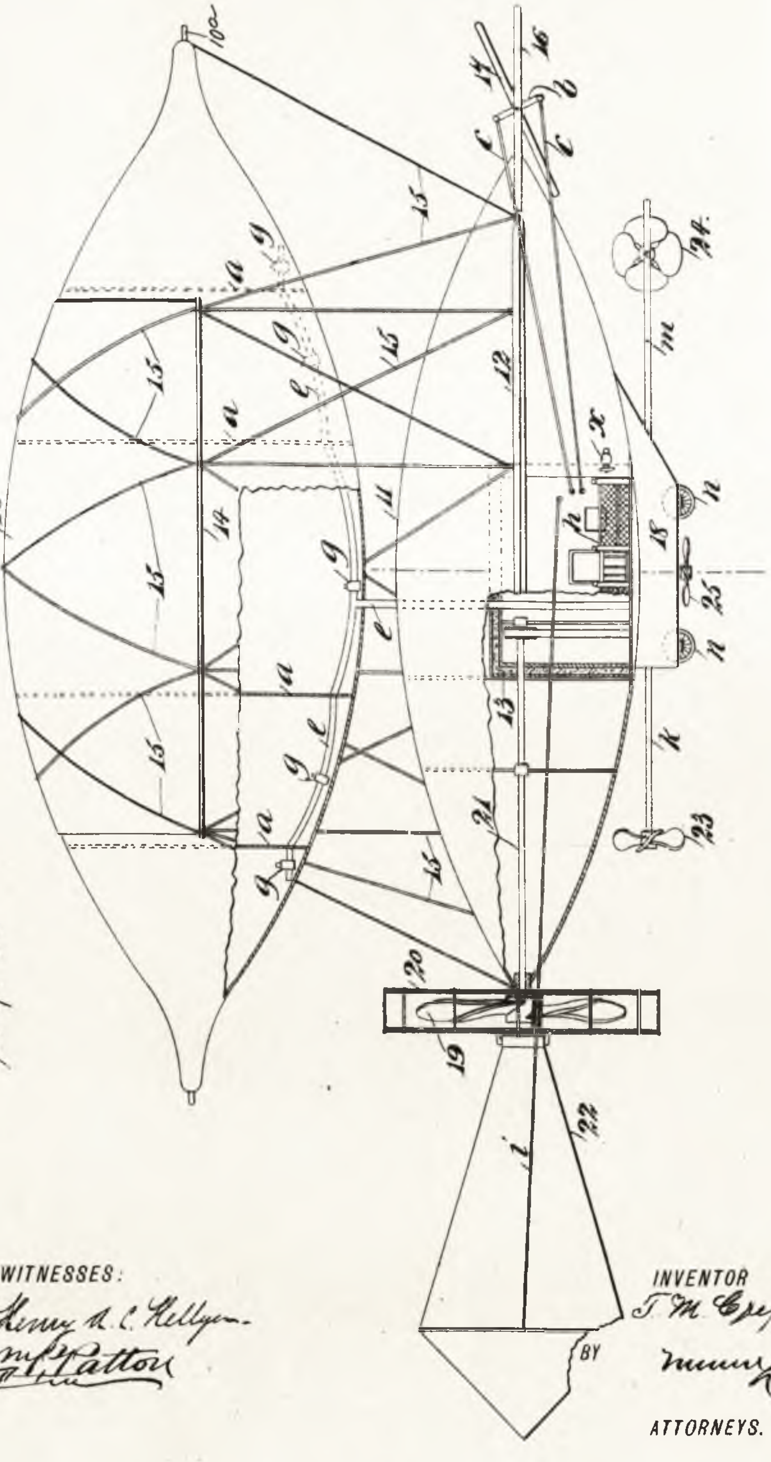


Fig. 1.

WITNESSES:

Henry A. C. Hellyer.

Wm. P. Patton

INVENTOR

T. M. Crepar.

BY

Munn & Co

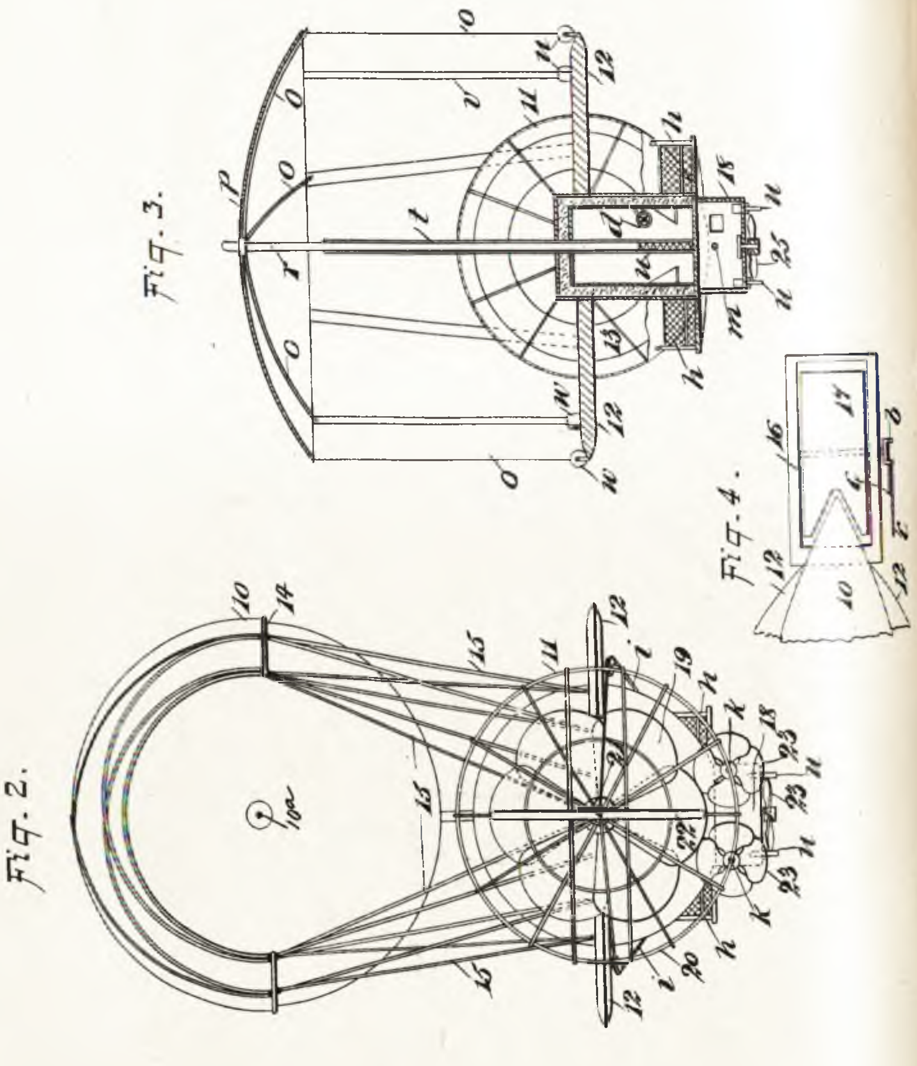
ATTORNEYS.

(No Model.) 2 Sheets—Sheet 2.

T. M. CREPAR.

AIR SHIP.

No. 588,556. Patented Aug. 24, 1897.



WITNESSES:

Henry A. C. Hellyer

Wm. P. Patton

INVENTOR

T. M. Crepar

BY

Munn & Co

ATTORNEYS

United States Patent Office.

THOMAS M. CREPAR, OF GRAND RAPIDS, MINNESOTA.

AIR-SHIP.

SPECIFICATION forming part of Letters Patent No. 588,556, dated August 24, 1897.

Application filed April 14, 1896. Serial No. 587,438. (No model.)

To all whom it may concern:

Be it known that I, THOMAS M. CREPAR, of Grand Rapids, in the county of Itasca and State of Minnesota, have invented certain new and useful Improvements in Air-Ships, of which the following is a full, clear, and exact description.

This invention relates to an improved device for aerial navigation, and has for its object to provide a novelly-constructed air-ship which will be adapted for control by operators sustained by it, whereby the traverse of the atmosphere in any desired direction at different heights is rendered practical.

The invention consists in the novel construction and combination of parts, as is hereinafter described, and defined in the claims.

Reference is to be had to the accompanying drawings, forming a part of this specification, in which similar characters of reference indicate corresponding parts in all the figures.

Figure 1 is a partly-sectional side view of the improved air-ship. Fig. 2 is a rear end elevation of the same. Fig. 3 is a transverse sectional view showing modified features of construction of a portion of the device; and Fig. 4 is a plan view of the forward end portion of the air-ship, showing a pivoted aeroplane forming part of the invention.

In Fig. 1 the flying-machine is represented as comprising two coacting main portions, of which 10 is the upper section and 11 the lower section. The section 10 consists of an elongated balloon constructed of any suitable material and having a conoidal formation at each end provided with removable plugs 10^a to afford means for removing atmospheric air while the balloon is being filled with gas, these plugs being replaced at a proper time to prevent loss of the gas that is introduced. The dimensions of the balloon 10, which is to be filled with gas that possesses maximum lifting power, should be proportioned to the weight to be supported, and preferably there are a number of compartments formed in it by the introduction of the spaced partitions a, which are secured by their edges to the inner surface of the balloon, as indicated in Fig. 1. The portion 11 of the air-ship is also elongated and rendered substantially conoidal at each end, its dimensions being proportioned to the requirements of the service to be performed, and within this part of the device, which is constructed of any light material suitable for the purpose, a walled cabin 13 for accommodation of passengers is located. The shell 11 is strengthened internally by any suitable means to adapt it to sustain the load it may have to carry, and at each side of said shell similar aeroplanes 12 are longitudinally extended and firmly secured, these being preferably formed of rigid material.

The balloon 10 is connected with the shell 11 by a flexible hanger-band 14, that is adapted to cover the upper portion of the ballon when the latter is inflated, and the said band has a network 15 of cordage applied to it and so secured thereto that pendent end portions of the net will be adapted to flexibly connect the shell with the balloon when the extremities of these pendent cords are affixed at intervals to the aeroplane 12, as shown in Figs. 1 and 2. At the front of the shell 11 a frame 16 is secured thereto by its rear end so as to project forwardly, and an aeroplane 17 is pivoted in the frame intermediately of its ends, so as to be rockable in a vertical plane.

An arm b is affixed between its ends on one projecting journal end of the pivot-shaft that sustains the aeroplane 17 on the frame 16, and two cords c or like flexible connections are respectively secured by one end of each to an end of the arm mentioned, these cords being rearwardly drawn through lateral perforations in the cabin 13, so that they may be attached to a hand-wheel device d, which by its rotatable support on the wall of the cabin will afford means for rocking the aeroplane 17 when the hand-wheel is manipulated. The main portion of the shell 11 is designed to be filled with gas having great lifting power—as, for example, hydrogen gas—and such gas is preferably introduced within the several compartments of the balloon 10 until all atmospheric air is expelled.

To effect the inflation of the balloon 10, a tubular conduit e is upwardly extended from the cabin 13, and at the upper extremity is branched in each direction, so that said lateral extensions will pass through the partitions a in an air-tight manner and lead gas from a source of supply to which the lower end of the conduit is connected and discharge it into each compartment of the balloon, such discharge being effected through check-valves g, that prevent return of the gas to the conduit. The provision of the plurality of compartments in the balloon 10 renders the latter more safe from collapse, as should any of such separate compartments be ruptured those remaining intact will still hold gas and aid in supporting other parts hung therefrom.

As indicated in Figs. 1 and 3, the cabin 13 is composed of double and spaced walls, these being of any light strong material, and preferably the cabin 13 is located near the longitudinal center of the shell 11, so that the ballast and machinery it may contain will be disposed in a manner that will avoid an improper distribution of the load in any direction. At each side of the cabin a balcony h is constructed by a lateral extension of the floor of said cabin, and they are inclosed at the sides with wire-netting to prevent occupants from being accidentally thrown therefrom while the air-ship is in motion, doors being provided in the cabin side walls to permit persons to pass onto the platforms or balconies. The space between the walls of the cabin is filled with wool or other heat non-conductor which will serve to prevent an excessive change of temperature that might result from the rise of the air-ship to a great elevation. Foldable seats or berths may be attached to the sides of the cabin, as shown in Fig. 3; or, if preferred, they may be hung to swing pendent from the ceiling for the accommodation of the occupants of the cabin.

Below the cabin 13 a power-room 18 is firmly secured to the floor of the same, this chamber being designed to contain the motors which are to be utilized for driving machinery required for the propulsion and control of the air-ship, and it may here be explained that any available motive power is to be employed.

It will be observed that the front of the power-room is sloped upwardly, so that frictional resistance to the forward movement of the device will be reduced to a minimum.

The main propeller-wheel 19, provided for the progressive movement of the air-ship, is located at the rear end of the shell 11 and is constructed in the usual form for such appliances, the weight of the same being reduced to the utmost limit permissible, so as to insure necessary strength and lightness. The wheel 19 is supported to rotate on the shell in a skeleton frame 20, that completely incloses said wheel and thereby prevents a contact with it of the balloon 10 in case the latter should be tipped rearwardly by force of air-currents that may be encountered while the air-ship is in motion.

The wheel 19 is affixed on the rear end of the horizontal shaft 21, that is journaled on the frame 20, and thence projects forward into the cabin 13 to receive rotary motion through a pulley thereon belted to any available engine or source of power and motion that is stationed below in the power-room. A rudder 22, constructed of light strong material and having correct proportions, is hinged by one end to the frame 20, so as to project its blade rearward and dispose it edgewise in a vertical plane.

Two flexible connections i are affixed at their rear ends, one on each side of the rudder 21, and thence forwardly drawn through the side walls of the cabin 13 for control of the rudder by an operator in the cabin. Below the shell 11 on the two horizontal shafts k, that are rearwardly projected from the power-room 18, two similar propeller-wheels 23 are mounted and secured, which wheels, with their shafts, are designed to receive rotary motion afforded by a suitable engine or the like located in the power-room. From the front of the power-room another shaft m is forwardly projected for support of a winged wheel 24, that is laterally held to rotate on said shaft or any suitable attachment thereto, and effective means (not shown) are provided to transmit motion from the power-room to the wheel 24. A propeller-wheel 25 is rotatably supported in a horizontal plane below the power-room 18, to be driven by any available motor in said room. At each side of the power-room 18 a pair of tandem wheels n are held to rotate, these four similar wheels being preferably of the same general construction as are bicycle-wheels, and portions of said wheels project below the floor of the power-room to adapt them for contact with the ground, the wheels being available to conveniently move the entire structure, except the balloon, into a desired position before the ship leaves the ground.

While it may be preferred to employ the balloon 10 as an aid for elevation of the air-ship to a proper height for progressive movement, it may in some cases be dispensed with and a parachute (shown in Fig. 3) be substituted therefor to facilitate the safe and easy descent of the air-ship. As shown, the parachute appliance consists, essentially, of a foldable frame o, covered with a light strong fabric p, secured to the frame, so as to be stretched taut when the latter is spread, the frame being properly mounted on a vertical shaft r, that slides in a tubular standard t and is seated on a spring u, placed within the standard at its base.

The hollow standard t is sustained upright by its attachment to the floor and ceiling of the cabin 13, passing gas-tight through said ceiling, as indicated in Fig. 3, and it will be evident that the folding of the parachute will be adapted to compress the spring u. In order to conveniently draw the shaft r down, and thus compress the spring u while folding the parachute, cords or bands v are attached by one end of each to the outer ends of the parachute-frame o, and thence extended down to have the lower ends of the cords each affixed to a spring roller device w, which latter is adapted to take up slackness of the cords when they are drawn upon to fold the parachute.

It is only necessary that the gas-chamber of the ship represented by the shell 11 shall contain enough gas to overcome the weight of the shell and attachments thereto and the balloon 10 have a lifting capacity that will quickly elevate the entire ship to a desired height for free sailing movement.

The propeller-wheel 19 from its position and area is designed to communicate to the poised ship a progressive movement, while the smaller wheels 23, if simultaneously revolved in the same direction as the wheel 19, will coact therewith for the propulsion of the air-ship.

It will be apparent that by changing the direction of rotative movement for the wheels 23—that is to say, run one with the wheel 19 and the other in an opposite direction—the direction of the ship will be diverted from a straightforward movement, so that measurable control of the direction of the sailing craft will be afforded. It is also obvious that with the wind in the right direction the adjustment of the rudder 22 will coact with the twin screw-wheels 23 in steering the ship. By an adjustment of the aeroplane 17 the shell 11 and parts hung from and carried by it will be caused to receive an upward or a downward inclination and thus correspondingly control the direction of the air-ship in a vertical plane.

It will be obvious that the rotation of the winged wheel 24 will have a tendency to push the bow of the ship laterally, and as said wheel is to be run in either direction by suitable means the sailing craft may therewith be turned to head it in a desired direction. Should the balloon 10 be dispensed with and the parachute be attached in lieu of it, the rotation of the wheel 25 in a proper direction, together with the inclination of the aeroplane 17, will enable the operator to raise or lower the air-ship, as may be desired.

In case of accident and the ship should become unmanageable by the described means the parachute may be employed to gently lower the entire structure, in which case gas in sufficient quantity may be withdrawn from the shell 11 through a valve x, (shown in Fig. 1,) which valve will also be of service for filling the shell 11 and also as a means for preventing improper strain on the shell should the gas in it be dangerously expanded in volume by the heat of the sun.

Having thus described my invention, I claim as new and desire to secure by Letters Patent—

1. An air-ship having a gas-shell, an aeroplane running around the sides of the gas-shell, a cabin projecting upwardly from the bottom of the gas-shell and into the interior thereof, the cabin opening at the sides of the gas-shell and having a power-room beneath it, and propelling and controlling devices running from the cabin and power-room to the exterior parts of the shell, substantially as described.

2. An air-ship having a gas-shell, an aeroplane running around the sides of the gas-shell, a frame held at the front of the gas-shell and in horizontal alinement with the aeroplane, a rocking aeroplane mounted within the frame and coacting with the first-named aeroplane, and means for controlling the rocking aeroplane, substantially as described.

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Witnesses:

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DELLA BROWN

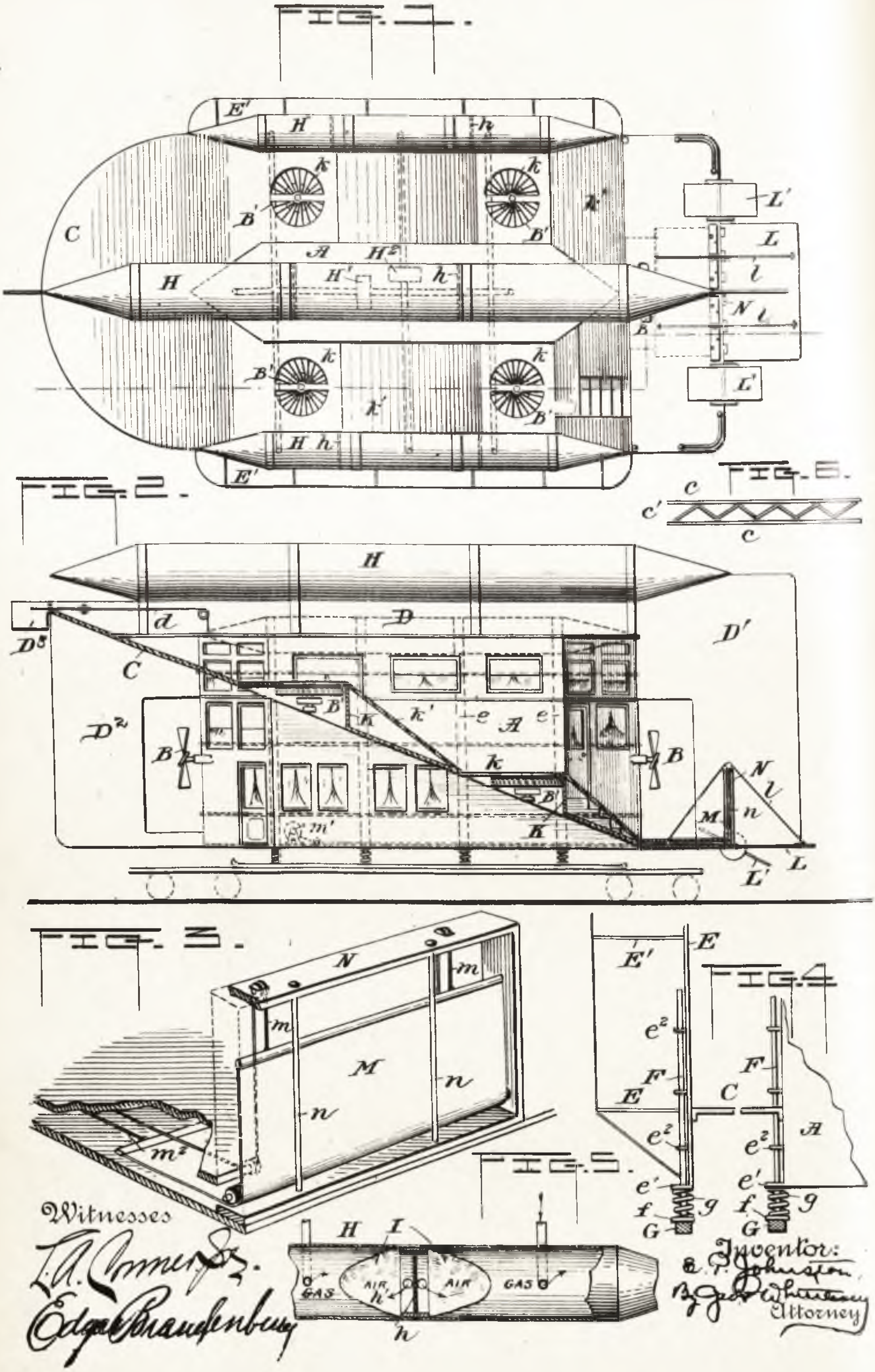
No. 722,516. PATENTED MAR. 10, 1903.

E. P. JOHNSTON.

AIR SHIP.

APPLICATION FILED OCT. 18, 1894.

NO MODEL. 3 SHEETS—SHEET 1.



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Inventor:

E. P. Johnston

By [illegible]

Attorney

No. 722,516. PATENTED MAR. 10, 1903.

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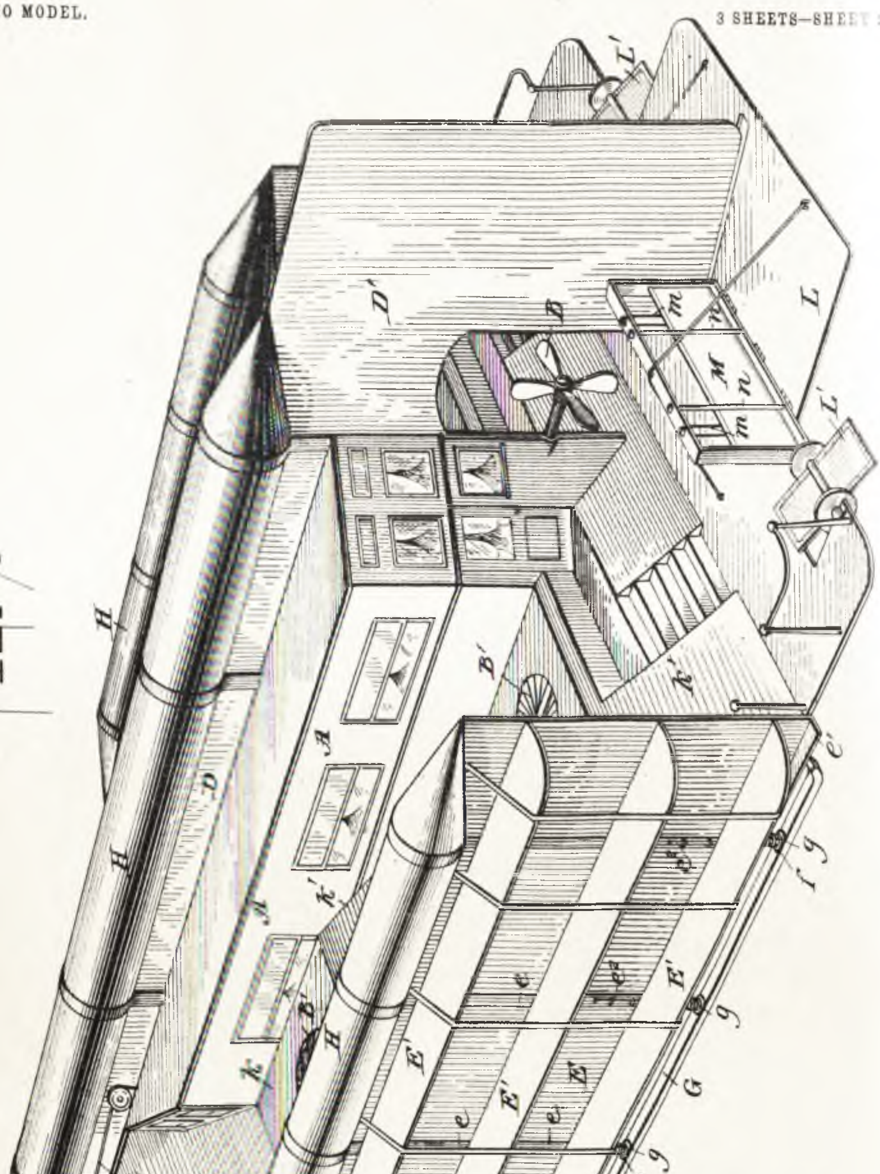
AIR SHIP.

APPLICATION FILED OCT. 18, 1894.

NO MODEL. 3 SHEETS—SHEET [illegible]

FIG. 7.



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No. 722,516. PATENTED MAR. 10, 1903.

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AIR SHIP.

APPLICATION FILED OCT. 18, 1894.

NO MODEL. 3 SHEETS—SHEET 3.

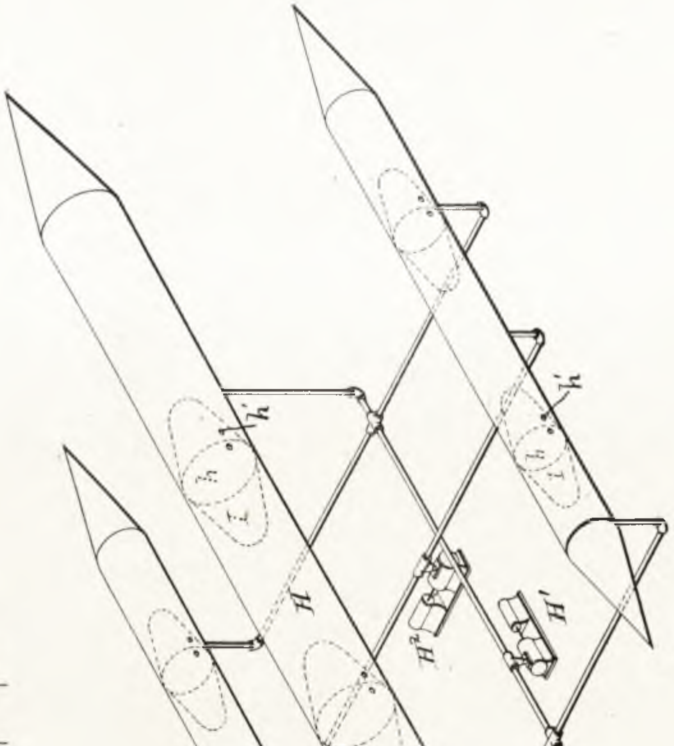

FIG-8-

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UNITED STATES PATENT OFFICE.

EDWARD PAYSON JOHNSTON, OF HIGHLANDS, COLORADO.

AIR-SHIP.

SPECIFICATION forming part of Letters Patent No. 722,516, dated March 10, 1903

Application filed October 18, 1894. Serial No. 526,299. (No model.)

To all whom it may concern:

Be it known that I, EDWARD PAYSON JOHNSTON, a citizen of the United States, residing at Highlands, in the county of Arapahoe and State of Colorado, have invented certain new and useful Improvements in Air-Ships; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

My invention relates to aerial navigation, and particularly to that class of air-ships which are elevated and sustained in the air by a series of elongated gas-holders in combination with lifting propeller-wheels and also by the pressure of the atmosphere against an inclined plane when propelled against it by driving-propellers. The ship is further maintained in its normal position and direction by a series of equilibrium-partitions, some upright and others extending laterally. It is in some respects similar to the air-ship shown and described in my Patent No. 383,889, upon which the present invention is designed as an improvement.

In the drawings, Figure 1 is a plan view of my air-ship. Fig. 2 is a vertical side elevation, partly in section, showing the ship supported upon a wheeled car. Fig. 3 is a perspective view, partly broken away, of one of the curtain-brakes. Fig. 4 is an elevation of the lower corner of the hull and the bottom of the adjacent equilibrium-partition, showing the yielding sills. Fig. 5 is a sectional elevation of a portion of one of the gas-receptacles. Fig. 6 is a section of the aeroplane. Fig. 7 is a perspective view. Fig. 8 is a perspective view of the gas-holders and their connecting pipes and pumps.

The same letters indicate like parts in all the figures.

The hull A of the air-ship is rectangular in cross-section and also in longitudinal section, except that both ends of the hull are wedge-shaped, the thin edges standing vertically. The hull is provided with suitable doors and windows and contains the machinery for actuating the propelling and lifting wheels or propellers B B'. A fixed inclined aeroplane C intersects the exterior of the hull A at an angle to its longitudinal axis, being higher at the forward end. It extends beyond the hull A in front, in rear, and on each side. A fixed vertical equilibrium-partition D extends longitudinally above the front part of the inclined aeroplane C and also above the hull of the air-ship along its central line as far as its rear end. From the rear of this partition and from the rear end of the hull, extending above and back of the inclined aeroplane, is the vertical equilibrium-partition D'. Below the forward part of the inclined aeroplane and extending forward from the front end of the hull is the equilibrium-partition D^2. At the front end of the partition D is the vertical rudder D^3, which is controlled by suitable tiller chains or ropes *d*, running over pulleys to the hull A.

On each side of the ship, above and below the fixed inclined aeroplane C, is an upright equilibrium-partition E, preferably located at or about the outer edge of the inclined aeroplane C and parallel with the partitions D D^2. The upper and lower edges of the partitions are preferably in the same planes as the top and bottom of the hull. They are stiffened by posts or battens *e*. Along the lower edges of the side equilibrium-partitions and also on each side of the bottom of the hull are yielding supports for the air-ship to rest upon when not in use. These are preferably constructed as shown in Figs. 2 and 4, each side partition having a bottom flange *e'*, perforated at intervals to permit rods F to pass through. Rings or other guides e^2 keep the rods in place. The lower ends of the rods are fastened to a sill or foot G, and between this sill (or a shoulder *f* on the rod) and the flange *e'* are helical springs *g*, surrounding the rods F and affording a yielding support for the ship. Similar sills, springs, and rods are provided along each side of the bottom of the hull.

The side equilibrium-partitions E are provided with a tier of outwardly-extending equilibrium-partitions E', parallel with each other and projecting out from the partition E. These serve to maintain the permanency of position and equilibrium of the air-ship resisting any rolling tendency. These up right and outwardly-extending equilibrium-partitions are designed to divide the current of air in order that the pressure of the atmosphere on either side may serve to aid in maintaining the equilibrium and increase the steadiness of the air-ship.

Along the upper edges of the central and side partitions D E are fixed the gas-receptacles H, the middle one being preferably the longest. Each receptacle is divided into three compartments by means of transverse partitions h. The end compartments are all connected by pipes with a pump H′, and the middle compartments are likewise connected with a pump H^2. Whenever one end or one side of the air-ship becomes elevated above its normal and safe position, gas is pumped from the compartments at that end or that side of the ship into the compartments at the lower end or side, thereby restoring the equilibrium. The gas-receptacles may be made of elastic material, so as to expand when gas is pumped into them, and thus displace a greater volume of air, or they may be made of rigid material with an expansible air-bag inside of each, as shown in Fig. 5. On each side of the partition h is a bag I, of flexible or elastic material, the mouth of which communicates by an opening h' with the outer air. This bag acts as an elongated elastic diaphragm, inclosing at one end of the compartment the volume of gas contained therein, and it is capable of movement either inward or outward, according as the volume of gas in the compartment is diminished or increased. This bag or diaphragm operates automatically. When gas is pumped out of the compartment, the air enters the opening and distends the bag, thereby taking up the space previously occupied by the gas. When the gas is pumped in again, the air is forced out of the bag by the pressure of the gas.

The wheels B B′ may all be driven by one or more suitable motors arranged so that each propeller shall be capable of being independently regulated, or each wheel may have its own independent motor. The mechanical connection between motor and propeller may be as indicated in my patent above mentioned, and therefore is not illustrated. The number of driving or lifting propellers may be varied as desired; but the driving propeller-wheels B are preferably two in number, one at the front of the hull A below the inclined aeroplane C and one at the rear above said aeroplane. They revolve in vertical transverse planes. The lifting propeller-wheels B′ are preferably four in number and are arranged symmetrically in horizontal planes on either side of the longitudinal axis of the ship. They are preferably located in wells K, inserted in openings in the fixed inclined aeroplane C between the hull and the side partitions E. A level floor k surrounds the top of each well, and an inclined section k', equal in width to the space between the hull and the side partition E, extends from the rear edge of the floor down to the inclined aeroplane C. The floor k and the section k' insure a smooth surface for the passage of the air along the top of the ship. The wheels B′ are supported in suitable bearings and are connected with a suitable motor within the hull or are independently connected with individual motors. The prime function of these wheels is to assist in lifting the air-ship at the start and supporting it in the air until a high rate of speed is attained by the driving-propellers.

To the rear of the inclined aeroplane is hinged a horizontal rudder or elevation-regulator L, which is operated by cords l and serves to control and maintain the desired angle of elevation of the ship. At each side of the regulator L are smaller horizontally-hinged blades L′, which are also under control of the engineer and serve to elevate or depress either side of the ship, and thus aid in maintaining the equilibrium.

For the purpose of suddenly checking the progress of the ship the blades L′ may be turned into a vertical position. In addition to these a powerful brake is provided, consisting of a stout curtain M, of flexible material, which can be drawn up in a frame N by means of cords m, running over suitable pulleys to a drum m'. The frame N stands upright just forward of the regulator L, and has rods n to support the curtain against the pressure of the air upon its front surface. Cords m^2 serve to draw down the curtain into the space between a double floor at the rear of the inclined aeroplane C. When raised, the curtain presents a large resistance to the air and rapidly retards the motion of the ship.

It will be understood that all parts of the ship are suitably braced to withstand strains. The bracing has not been fully shown because it would confuse the drawings and because it is a structural detail which any builder would expect to introduce without special instruction.

The method of operating my air-ship is as follows: The lifting-wheels are put in motion, supplementing the gas-receptacles in elevating the air-ship above the obstacles that might oppose its progress. Power is then applied to the driving-propellers. As the speed of the air-ship is increased the power applied to the lifting-wheels is gradually diminished, as the weight of the air-ship in addition to the lifting power of the gas employed will be largely supported by the pressure of the atmosphere against the inclined aeroplane when propelled forward rapidly.

The effect of the lifting-wheels will be greatly increased when the air-ship is moving rapidly by the pressure of the currents of air forced downward through the wheel-wells against the surface of the powerful currents of air passing beneath the inclined aeroplane on either side between the equilibrium-partitions and the sides of the hull. The pressure of these confined currents of air against the under surface of the inclined aeroplane is greatly increased by the wedge-shaped forward part of the hull, which forces twice the quantity of opposing atmosphere into the adjacent narrow passages on each side of the hull.

The equilibrium-partitions D, D', D², E, and E' serve to give a steady normal equilibrium to the air-ship. Equilibrium is further maintained by using the air-pumps to elevate either side or end of the air-ship when unduly depressed.

In descending to the ground the power applied to the driving-propellers is gradually diminished while that applied to the lifting-wheels is increased, and the curtain-brake M being brought into use the speed of the air-ship is gradually diminished while descending to the ground or station.

Having thus described my invention, what I claim, and desire to secure by Letters Patent, is—

1. The combination with the hull of an air-ship, of a fixed inclined aeroplane, upright side equilibrium-partitions parallel with the hull and extending above and below said inclined aeroplane, wheel-wells in the inclined plane between the hull and the side partitions, horizontal lifting-wheels in said wells, and a driving-wheel below the inclined aeroplane at the front of the ship, substantially as described.

2. In an air-ship the combination of a hull A, a fixed inclined aeroplane C, a series of lifting-wheels located in wheel-wells extending through the air-ship, and one or more driving-propellers located in front of said hull beneath the forward part of said inclined aeroplane, with one or more driving-propellers located at the rear end of the hull above the rear part of said inclined aeroplane, substantially as described.

3. The combination with the hull of an air-ship, of a fixed inclined aeroplane, upright side equilibrium-partitions parallel to the hull, wheel-wells in said inclined aeroplane between the hull and the partitions, floors k surrounding the wells, inclined sections k' uniting said floors with the fixed inclined aeroplane, and horizontal lifting-wheels in said wells, substantially as described.

4. In an air-ship, the combination of a hull A, a fixed inclined aeroplane C, a series of lifting propeller-wheels located in wheel-wells extending through the air-ship, and one or more driving-propellers, with the equilibrium-partitions E having the series of normally horizontal equilibrium-partitions E' extending outwardly therefrom, substantially as described.

5. In an air-ship, the combination of a series of lifting-wheels and one or more driving-propellers, with the curtain-brake M, and means for rolling up said curtain more or less at will, substantially as described.

6. In an air-ship, the combination with the hull, of a fixed inclined aeroplane, upright side equilibrium-partitions parallel with said hull, guides on said partitions, rods sliding in said guides, a sill fastened to the lower ends of said rods, and helical springs between said sill and the lower edge of the side partition, substantially as described.

7. In an air-ship, a brake consisting of an upright frame and a flexible curtain adapted to be raised and lowered in said frame, substantially as described.

8. In an air-ship, a brake consisting of an upright frame, a flexible curtain adapted to be raised and lowered in said frame, cords for operating said curtain, and a drum to which said cords are connected, substantially as described.

9. In an air-ship, the combination of a series of lifting-wheels located in wheel-wells, extending through the air-ship and one or more driving-propellers, with one or more elongated gas-receptacles attached longitudinally above the air-ship, substantially as described.

10. In an air-ship, the combination with the hull, of a fixed inclined aeroplane, a central upright equilibrium-partition, two vertical side equilibrium-partitions, and a gas-receptacle secured to the upper edge of each partition, substantially as described.

11. In an air-ship, gas-receptacles divided into compartments, pipes connecting said compartments, and one or more pumps connected with said pipes, whereby the volume of gas in any compartment can be changed, substantially as described.

12. In an air-ship, a longitudinal gas-receptacle divided by transverse partitions, and means for transferring gas from one end to the other of said receptacle, whereby the equilibrium of the ship may be controlled, substantially as described.

13. In an air-ship, parallel longitudinal gas-receptacles located on either side of the ship, and pumps for transferring gas from one to the other, substantially as described.

14. In an air-ship, the combination with two or more gas-receptacles divided by two transverse partitions, of pipes, connecting the end compartments, a pump connected with said pipes, and a pump connected with the middle compartments, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

EDWARD PAYSON JOHNSTON.

Witnesses:
WILLIAM O. TRASK,
D. P. SAUNDERS.

CERTIFICATE NOT PRINTED

No. 666,427. Patented Jan. 22, 1901.

C. H. LAMSON.

KITE.

(Application filed May 9, 1900.)

(No Model.) 3 Sheets—Sheet 1.

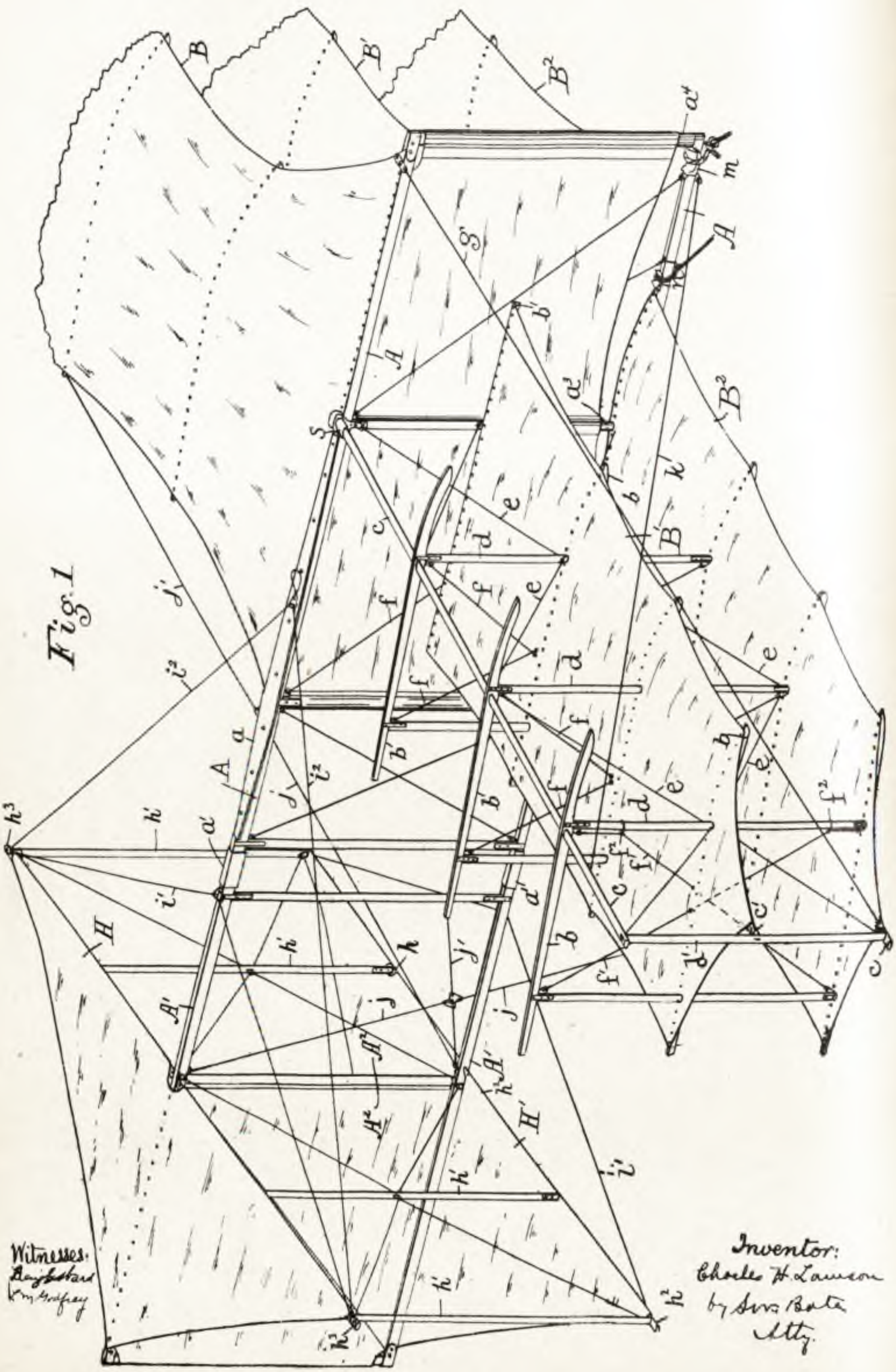

Fig. 1

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No. 666,427. Patented Jan. 22, 1901.

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KITE.

(Application filed May 9, 1900.)

(No Model.) 3 Sheets—Sheet 2.

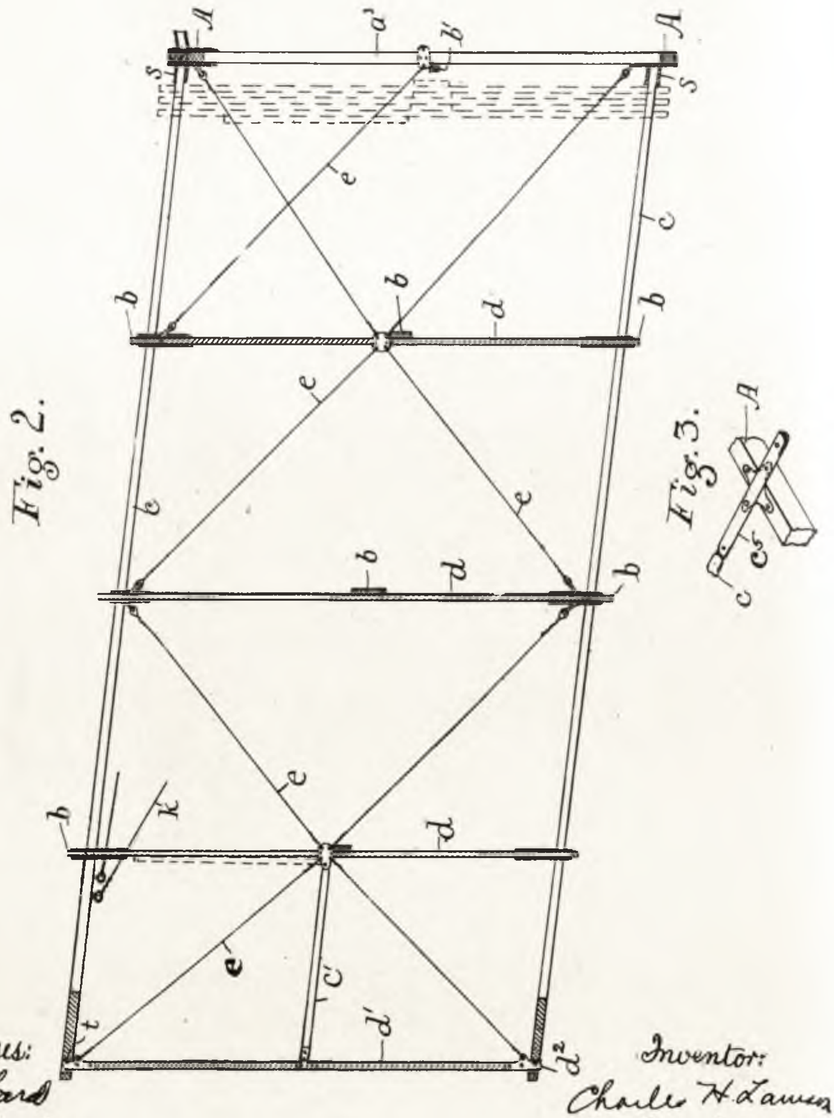

Fig. 2.

Fig. 3.

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No. 666,427. Patented Jan. 22, 1901.

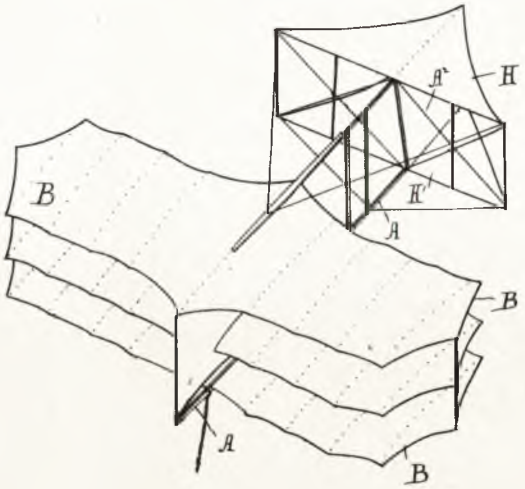
C. H. LAMSON.

KITE.

(Application filed May 9, 1900.)

(No Model.) 3 Sheets—Sheet 3.

Fig. 4.



Witnesses:
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Philip Dorticos

Inventor:
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UNITED STATES PATENT OFFICE.

CHARLES H. LAMSON, OF PORTLAND, MAINE.

KITE.

SPECIFICATION forming part of Letters Patent No. 666,427, dated January 22, 1901.

Application filed May 9, 1900. Serial No. 16,003. (No model.)

To all whom it may concern:

Be it known that I, CHARLES H. LAMSON, a citizen of the United States of America, and a resident of Portland, in the county of Cumberland and State of Maine, have invented certain new and useful Improvements in Kites, of which the following is a specification.

My invention relates to what are known as "ribbed aerocurve kites;" and it is particularly designed for use in carrying aloft meteorological instruments for making observations in the upper atmosphere and for other like purposes. These kites have curved wings or planes which in flight are kept in a position slightly inclined to the horizontal by a tail or rudder, which may be in the rear or both front and rear, the proper conformation of the wings being rigidly maintained by curved ribs suitably spread.

One object of the present invention is to construct a kite of this class so that it may be closely packed for shipment or handling, and also so that the inclination of the wings may be readily adjusted and balanced one against the other.

A further object is to prevent the kite from diving or turning over on its side or flying at an angle with the direction of the wind in case it is out of balance or for any other reason.

These objects I attain by means of the features hereinafter shown and described.

I illustrate my invention by means of the accompanying drawings, in which—

Figure 1 is a perspective view of my kite with the covering and wire edges removed from the upper wing on one side. Fig. 2 is a vertical section taken through one wing from the tip to the base. Fig. 3 is a perspective view of a modification of one of the details, and Fig. 4 is a perspective view showing the general appearance of the kite.

As shown, the kite is composed of an elongated frame A, forming the keel or center, with one or more wings composed, preferably, of curved surfaces extending out at each side in a generally horizontal position, and a tail or rudder at the rear end of the frame. The frame A, as shown, is in the form of truss having upper and lower chords with uprights, as a^3 and a^4, and diagonal tie-wires. Near the forward end on the lower chord are two saddles m and n, to which holding-chords may be attached, the forward one being used for handling the kite when the kite is near the ground and the rear one is for the main or lifting line and when it is fully up. The wings, as shown, are composed of three superposed curved planes B, B', and B^2 on each side of the central frame supported on arms c, which may be straight, as here shown, or slightly curved, if desired, one of said arms extending out from the upper chord, the inner ends of the arms fitting into sockets s, from which they are readily removable. The inner ends of the arms may be secured to the central framework by other means than those here shown or by hinges, as shown in Fig. 3. The wings or planes are formed of ribs b, having a covering of cotton cloth or other suitable fabric tacked to their upper edges. The covering is applied with wires inclosed in the edges in the well-known manner. The upper and lower sets of ribs, as shown, have openings through which pass the arms c, which are in the form of flattened oval bars, and the ribs are adapted to slide on these bars. The intermediate sets of ribs are attached to vertical posts d d, which are fastened to the upper and lower ribs, forming, with the diagonal tire-wires f f, a series of panels adapted to be folded in against the sides of the frame by sliding on the bars c. Diagonal tie-wires e brace the series of panels in the direction of the arm c, and the outer ends of the arms are connected by an upright d', which is made detachable, so that the arm c may be drawn out separately and disconnected from the kite for convenience in packing.

As shown in Fig. 3, the inner end of the arm c is hinged to a projection c^5, which extends out from the chord and which is long enough to receive all of the panels when they are folded against the frame. The hinge connection of the arm being thus outside of the folded panels, the arm may be folded in against the frame without being removed.

In order to detachably connect the upright d', it is provided at each end with a fastening-plate d^2, with a lateral recess fitting over a pin t, which passes through the arm c. The arm c has a slot large enough to receive the plate d^2 and to allow the notch t to pass over the pin. The upright d' is connected with the folding panels by diagonal tie-wires e, so that it folds in with the panels when the arms are removed.

To furnish a support for the tip of the central wing, I provide a short arm c', which is hinged by its inner end to the nearest upright d, the outer end being provided with a notched plate fitting into a slot in the upright d' and engaging a pin which passes transversely through said slot. The upright is disconnected from the arms c by pulling it slightly out against the pull of the diagonal braces and disengaging the plates d^2 from the pins t.

As here shown, the coverings, which form the wings proper, are glued and tacked or otherwise secured to the upper surfaces of the ribs, and the points of the wings are stretched and hooked onto suitable fastenings provided near the ends of the arms c c and c'. If desired, the covering may be applied to the lower surfaces of the ribs or to the upper and lower, or both. The inner ends of the wings are tacked to central ribs or ledges b', secured along the frame A.

As here shown, the ribs, which give form to the wings, are approximately straight from the arm c to their rear ends, and forward of the arm they curve downward, so that the wing has a greater curvature at its front edge than at its rear, the outer ribs being less curved than the inner ones. For the purpose of giving the kite lateral stability the outer tips of the wings are shown as somewhat above the level of the inner ends, so that the wings have an upward inclination from the center outward.

For the purpose of giving the kite additional lateral stability when in the air and for preventing it from diving if accidentally canted on its side, also to obtain an advantageous point of attachment for the flying line as well as for the bracing-guys, I cause the forward end of the central frame, or what might be called the "bowsprit," to project forward beyond the forward edges of the wings. This bowsprit also affords a framework for a keel or vertical support at the front, so that if the kite turns on its side the wind gets under the projecting portion of the frame and tends to support and right it. The frame A is provided with a proper covering extending from the bowsprit as far back as the rear edges of the wings, the kite being thus steadied and dangerous side movements checked. The horizontal covering at the top is also shown carried out to the point of the bowsprit as a front rudder and additional support.

In order to properly balance the wings on each side, I provide means for tilting or inclining the outer ends to a greater or less extent. A general adjustment is made by guys k, each of which is secured at the front lower corner of the frame A and at the under side of the upper arm c by screw-eyes, as shown in Fig. 2, or by other suitable means. By adjusting the position of these screw-eyes a general adjustment of the wings on each side may be made. A more delicate adjustment is obtained by the means here shown for changing the vertical inclination of the ribs in the outer panels of the wings. This is accomplished by loosening one of the diagonal tie-wires of the panel and tightening the other. The simple means here shown for accomplishing this result are two loops f^2, adapted to slide on the uprights d, each of the two diagonal tie-wires passing through one of these loops. By sliding both of these loops up or down the inclination of the ribs to the horizontal is adjusted with great precision.

For the purpose of holding the kite at the proper inclination to the wind I provide a tail or rudder, here shown as consisting of two triangular planes H and H', extending out at each side of the central frame, and a vertical plane A^2, formed by covering the space within the rear portion of the central frame. The fabric of the planes H and H' is secured along the central frame and to outward-extending arms h^2 and h^3, which are hinged to the central frame, so that they fold back against it for convenience in packing. Uprights h' h' are provided, connecting the pivoted arms h^2 h^3 the upper with the lower, and wire braces i' stay the outer ends of the arms h^2 and h^3. The tail is detachably connected to the main kite by means of ferrules a', applied to the upper and lower chords of the central frame, and it is otherwise secured by wire braces i^2, j, and j'. For the purpose of rendering the chords stiff laterally I secure to them flat stringers a at approximately the middle point.

It will be understood that as many superposed wings as desired may be used on each side of the center, although I prefer to make a kite with three pairs of wings, as here shown.

It will be understood that while this construction is primarily designed for a kite to be used for carrying meteorological instruments for raising signals or advertising devices or other like purposes it is also capable of use as a flying-machine by the application of suitable propelling and guiding mechanism.

The feature here shown of the ribs so mounted on the transverse arm as to slide together for the purpose of packing, &c., may be utilized in other forms of kite.

I claim—

1. The herein-described kite having one or more transverse arms, ribs adapted to slide on said arms, a covering for said ribs and means for holding the ribs extended on said arms and the covering stretched on said ribs.

2. The herein-described kite having a central frame, arms extending horizontally out from each side of the frame, ribs adapted to slide on said arms and to fold against said frame, a covering for said ribs and means for holding said ribs extended on said arms and said covering stretched on said ribs.

3. The herein-described kite having a central frame, arms extending horizontally out

from said frame on each side, one at the top and one at the bottom of the frame, ribs adapted to slide on said arms, corresponding ribs on the upper and lower arms being connected by a framework to form panels adapted to fold against said central frame, a covering for said ribs and means for holding said panels extended on said arms and said covering stretched on said ribs.

4. The herein-described kite having a central frame, arms extending horizontally out from said frame on each side, one at the top and one at the bottom of said frame, ribs adapted to slide on said arms, vertical posts connecting corresponding ribs on the upper and lower arms and wires forming with said ribs and posts panels adapted to fold against the said central frame, ribs secured to said panel between the top and bottom members, coverings for said ribs and means for holding said panels extended on said arms and said covering stretched on the ribs.

5. The herein-described kite having a central frame, wings projecting out from each side of said frame and means for tilting the tips of said wings with relation to the body of the wing.

6. The herein-described kite having a central vertical frame, wings projecting out at each side of said frame composed of arms attached to the frame, a series of upright panels connected with said arms having vertical members composed of posts connecting said ribs and diagonal tie-wires and loops through which the wires pass adapted to slide on said vertical members to regulate the inclination of said ribs and the inclination of the wing.

Signed at Portland, Maine, this 3d day of May, 1900.

CHARLES H. LAMSON.

Witnesses:

BENJ. G. WARD,

L. M. GODFREY.

A.D. 1868, *5th February.* N° 392.

Aërial Locomotion, &c.

LETTERS PATENT to Matthew Piers Watt Boulton, of Tew Park, in the County of Oxford, Gentleman, for the Invention of "IMPROVEMENTS IN PROPULSION AND IN AERIAL LOCOMOTION, AND IN APPARATUS CONNECTED THEREWITH, PARTS OF WHICH ARE APPLICABLE TO PROJECTILES AND TO BOILERS.

Sealed the 4th August 1868, and dated the 5th February 1868.

PROVISIONAL SPECIFICATION left by the said Matthew Piers Watt Boulton at the Office of the Commissioners of Patents, with his Petition, on the 5th February 1868.

I, MATTHEW PIERS WATT BOULTON, of Tew Park, in the County of Oxford, Gentleman, do hereby declare the nature of the said Invention for "IMPROVEMENTS IN PROPULSION AND IN AERIAL LOCOMOTION, AND IN APPARATUS CONNECTED THEREWITH, PARTS OF WHICH ARE APPLICABLE TO PROJECTILES AND TO BOILERS," to be as follows :—

This Invention relates to propulsion, more particularly to that of vessels and bodies moving through the air, to the generation of the motive force employed, and to the construction of boilers to be used in aerial locomotion, some of these boilers being applicable to general purposes.

It has for its objects to obtain and apply motive power for propulsion without the weight of engines or heavy moving mechanism, to provide security, and to obtain lightness of construction.

It would be very advantageous to employ the motive power of aeriform jets for the propulsion of aerial vessels if this could be done without excessive loss of power, as in such a mode of propulsion the weight of engines and heavy moving mechanism is dispensed with; but if the simple issue of the jet, as in a rocket, is used for the purpose the loss of power is excessive.

In order to employ the power more efficiently I adopt the following construction :—I cause the jet to issue towards the hinder part of the vessel from an orifice contained in a body so shaped as to offer little resistance to the passage of air. The hinder part of this body near the issue of the jet is a solid of revolution hollowed out or of concave section. The jet issues into a tube or passage communicating freely with the air, so that the jet causes a current of air to flow through it from front to stern. This passage is trumpet mouthed in front, and is a central cavity in a body, which is a solid of revolution tapering from front to stern, being hollowed out or having a concave section at the stern. The action of the current of air drawn or caused to move by the jet through the passage produces reduction of pressure on the front of the body in which the passage is situated, while this reduction does not take place behind it, and thus unbalanced pressure is produced urging the body forwards. This propulsive effect is added to that of the original jet. Cylindrical guides of successively larger size may be employed to guide the air to the jet so as to divide it into currents of different velocities. Instead of employing only one passage and body as previously described successive bodies and passages of successively increasing size may be used. In such a case the curvature of the lateral openings is varied to suit the different velocities of the inflowing currents, the amount of this curvature being in each case greater as the body is nearer to the jet and the velocity of inflow greater.

Another mode of employing the jet is as follows :—A body and passage having a form similar to that previously described is provided, and the jet is caused to issue from an annular orifice within the passage so as to flow over its interior surface, and to cause a current of air through it which acts by reduction of pressure in front in the manner already described. In this, as in the preceding case, guides may be employed dividing the air into currents of different velocities.

Again, an annular jet may be caused to issue, so that air has free access both to its exterior and interior, and thus the two modes above described may be combined, the current of air set in motion by the jet flowing through a passage in a body such as previously described. Instead of an annular jet a number of separate jets disposed circularly may be employed.

The following is another mode of employing a jet so as to produce propulsive effect:—A body is provided having the form of a solid of revolution tapered at the stern and prow or front. An annular jet of aeriform fluid is caused to issue at its fore part in front of its convexity, so as to mix with air and create a mixed stream which flows or sweeps over the convex surface, finally quitting it backwards. In this case the action of the jet causes reduction of pressure on the front, and thus produces propulsive effect.

Jets may be employed to act in a similar manner on the curved surfaces of bodies which are not solids of revolution; such, for instance, as the sides of marine vessels or portions thereof. Many jets or combinations of them may be employed, and they may be so disposed and regulated as to vary the velocity, direction, and balance of the vessel.

Liquid jets moving in liquids may be treated in a manner similar to that above described.

The action of jets employed as above explained may be used for general purposes of propulsion, but it is peculiarly suited for aerial locomotion, as in this case the loss of power attending it is compensated by reduction of weight, which for such a purpose is a matter of primary importance.

Again, jets acting as above explained may be employed for propelling projectiles.

Apparatus as above described may be employed to propel aerial vessels supported by balloons or vessels containing light or heated gases. It may also be employed to propel an inclined plane or surface, by the motion of which through the air upward pressure is produced and the vessel supported in the manner which is well understood and has often been described. Upward support may also be obtained by causing a current or currents produced by jets or by motive power of other kinds generated in the propelled body to impinge on a suitably inclined plane or surface or on several such surfaces suitably disposed. Currents may be employed which have previously produced propulsive effect. The velocity of the currents thus employed may greatly exceed the forward velocity of the vessel, so that the surface on which they impinge is acted on more forcibly. The same surface may be acted on both by the currents of high velocity, and also by the pressure caused by the forward movement of the vessel. The surface or surfaces may also be acted on by the wind producing propulsive effect, as in the case of birds. I prefer to give a curved form to the surface thus acted on, so that the fluid shall impinge upon it without shock, and be continually deflected while passing in contact with it. A curved surface may be acted on by a current or currents, so that both the actions previously described may be exerted on it simultaneously, that is to say, an upward pressure producing support and a propulsive action propelling in the direction required. The inclination and position of the surfaces may be altered so as to vary the amount and direction of the pressure, and thus to change the course or balance of the vessel. This mode of obtaining support for aerial vessels may be used whatever be the motive power employed to produce the aeriform current caused to impinge on the plane or surface.

Another mode of obtaining support is to cause the current produced by the action of the jets or other motive power to pass over the upper side of a plane or extended surface, so that pressure is reduced on its upper side. When the aerial vessel is supported by the buoyancy of gas a similar method may be employed for raising and lowering it. Also the different methods of obtaining support or counteracting gravity may be used in conjunction. When aerial vessels are thus supported they may under certain circumstances be guided by attaching to them a keel or keels moving through the sea so as to resist the action of a side wind, and enable the vessel to be steered in the course desired. When it is not desired to use this action the vessel may move at an altitude above the sea. Such a vessel may carry an apparatus for regenerating gas to replace loss by leakage. Vapour or products of combustion discharged after performing work or these mixed with air may be used for this purpose while the propelling power is in action.

The jets employed in the apparatus previously described may be jets of steam or of products of combustion or of these mixed with steam, and may be generated in various ways.

The following are methods which may be employed for this purpose: —Substances which do not require a supply of air for combustion, such as compounds of nitre with carbonaceous matter are introduced by a feeding apparatus into a vessel in which combustion is maintained. They are introduced into a cool part of the vessel, and subsequently moved to a hot part where the combustion goes on.

Another method of generating the aeriform fluid is as follows:— Two substances which when mingled are capable of producing combustion without a supply of air, such, for instance, as nitre and carbonaceous matter are introduced separately by feeding apparatus into a vessel in which combustion is going on, and by the supply of ingredients thus furnished the combustion is maintained. Liquids for this purpose may be fed from a pump. As examples of such liquids may be mentioned oils to supply carbon and hydrogen and nitric and chloric acid to supply oxygen and chlorine. The weight of water for the generation of steam and the weight of substances for supplying oxygen are both objectionable for the purpose of aerial navigation. In these respects there is advantage in using for the motive power inflammable gas or vapour mixed with air, as in this case the weight both of the oxygen and of the water is dispensed with.

In using this motive power for the production of jets, one mode of proceeding is as follows:—Inflammable gas or vapour is produced at high pressure by heating in a boiler a hydrocarbon or other suitable substance, and the aeriform fluid produced issues constantly in a jet from an orifice, this jet acting in an apparatus such as previously described, and creating a current of inflammable vapour mixed with air. This mixture is ignited, the expansion of the current thus caused increasing its energy and propulsive effect. The heated current may be treated for the production of propulsive or useful effect, as previously explained. A portion of its heat may be used to generate the inflammable gas or fluid. I prefer to employ liquids which vaporize without any solid residue; also, such as are converted into gas or vapour of high density, as these at a given pressure produce a jet of lower velocity and consequently of greater propulsive efficiency.

In the methods above described the jet flows continuously, in the one which I proceed to describe it acts intermittently. A jet of inflammable fluid draws air into a tube or chamber, filling this with an inflammable aeriform mixture. The tube or chamber is furnished in front with a valve opening inwards, so that when pressure is created within the tube the valve closes, while when the pressure is removed the valve opens and the inflammable fluid and air freely enter and flow along the tube. The motion of this valve also regulates the issue of the inflammable fluid from the vessel supplying it, so that the closure of the valve stops its issue, while its opening allows it to take place freely. The hinder part of the tube is furnished with a valve which opens when there is no pressure in the tube, so as to allow the free passage of a current through it, while when pressure is created in the tube this valve prevents exit of the fluid, except by a small orifice through which it issues with high velocity as a jet.

The action of the apparatus is as follows:—The tube or chamber being filled with non-inflammable fluid, and the valves at both ends being open, the inflammable fluid and air enter from the front, driving out the non-inflammable fluid and replacing it with an inflammable mixture. When the inflammable mixture has reached the hinder end of the tube, or a point near it, it comes in contact with a flame kept constantly burning and is ignited by it. The pressure thus produced inside the tube closes the valves at both ends, and thereby stops the flow of the air and of the jet, while the small orifice in the hinder valve remains open, and the products of combustion are forced by the pressure to issue through this as a jet with high velocity. This jet is treated as previously explained, so as to produce propulsive or useful effect. When by the issue of the products of combustion the pressure within the tube is removed the valves at both ends of it open, the inflammable mixture enters at the front, driving out the products of combustion, and the operation is repeated. Many tubes may be employed with jets acting simultaneously, and many jets may be employed acting at different times, so that a continuous propulsive effect is exerted. The action in this apparatus is not so simple as when the jets act continuously. The object aimed at in this method is that the heat may be applied to the fluid at high pressure and thus be employed more efficiently. It is also to be observed that in this plan the inflammable fluid is not generated at high pressure, and thus the boiler or generator may be light. A portion of the heat produced by the combustion may be utilized for generating the inflammable vapour or fluid.

In order to generate vapour of oils or hydrocarbons at high pressure for aerial propulsion, I prefer to employ the following construction of boiler: — Two vessels are employed, an upper and an under one, connected by numerous vertical tubes, round the exterior of which the flame plays while the vapour is generated within them. Circulation of the liquid is maintained by means of a pump or forcing apparatus. By the action of this the liquid is raised into a chamber or passage in the upper vessel, whence it constantly descends in small streams on the surface of the tube plate which forms its bottom, or on plates or surfaces a little above it, and thence flows constantly downwards over the interior surfaces of the tubes, and keeps these covered by a thin stream or film of liquid. The liquid thus flowing along the tubes is exposed to heat and gives off vapour, which rises through the central parts of the tubes. By such a construction difficulties arising from the viscidity of the oil or liquid employed are obviated. If steam is used for aerial propulsion a similar construction of boiler may be used, being light and compact and charged with a small weight of water.

The following is another form of boiler constructed with a view of securing lightness:—A cylindrical boiler is fitted with numerous tubular flues like the barrel of a locomotive engine. Opposite to the mouth of each of the tubular flues is the orifice of a tube communicating with a chamber containing inflammable fluid which issues from each of the orifices in a jet. The chamber is perforated with numerous tubes or passages, allowing a free flow of air through them. Each jet draws or forces air along with it into the tubular flue of the boiler opposite to it. In order to secure a more complete mixture of air with it, intermediate tubes may be placed between the jet orifices and the boiler tubes; the action of each creates an inflammable mixture in the tubular flue opposite to it which is ignited and passes through that flue, giving out heat to the liquid in the boiler. The jets which create this effect may be of various kinds, such as jets of inflammable gas or vapour, or jets of steam, or of air carrying along with them inflammable liquids in the form of spray or solids in the form of dust, as have been used in other constructions. In this construction the products of combustion act on the extended surface afforded by the numerous tubular flues at their highest temprature, and thus compactness and lightness of boiler are obtained. The boilers may be fitted with both longitudinal and transverse diaphragms to secure more rapid circulation of the liquid. Part of the heat of the fluid passing through the tubes may be used to generate the inflammable gas or vapour which may be employed in the jets. Boilers constructed as thus described may be used for various purposes, as for instance for marine and locomotive engines.

For the safety of aerial vessels it is important to provide a controlling power, not only to direct their horizontal and vertical course, but also to prevent their turning over by rotating on the longitudinal axis. A certain stability of the kind desired is afforded by using an extended surface whose sides make an angle from the axis upwards as has previously been described by others. But it is desirable to provide a more powerful action preventing rotation of the body in this direction. For this purpose a rudder of the following construction may be adopted:—Vanes or moveable surfaces are attached to arms projecting from the vessel laterally or at right angles to its length. When these vanes are not required to act they present their edges to the front, so as to offer little resistance to the vessel's movement, but if the vessel should begin to rotate on the longitudinal axis the vanes are moved so as to take inclined positions, those on the ascending side of the vessel being caused to rotate to such an inclination that the air impinging upon them exerts a pressure downwards, while those on the descending side are so inclined that the air impinging upon them exerts a pressure upwards; thus the balance of the vessel is redressed and its further rotation prevented. The vanes may be moved by hand or by self-acting mechanism. For this purpose a weight or heavy body is connected to the vessel which carries the vanes, so that the vessel may rotate on the longitudinal axis without imparting such rotation to the weight or heavy body. When rotation of the vessel in the direction described begins, the relative positions of the vessel and the heavy body change, and consequently by means of cords or other suitable connections between the heavy body and the vanes the required movement can be communicated to the vanes. Stability of the kind desired may also be attained by attaching to the upper side of the aerial vessel receptacles rendered buoyant by light or heated gases which may be replenished from time to time; these receptacles may be of small content, so shaped as to offer little resistance to the air.

Vanes acted on by self-acting mechanism of a kind similar to that above described may also be used when desired for keeping the vessel in a fixed course, both vertically and horizontally.

SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by the said Matthew Piers Watt Boulton in the Great Seal Patent Office on the 5th August 1868.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, Matthew Piers Watt Boulton, of Tew Park, in the County of Oxford, Gentleman, send greeting.

WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Fifth day of February, in the year of our Lord One thousand eight hundred and sixty-eight, in the thirty-first year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the said Matthew Piers Watt Boulton, Her special licence that I, the said Matthew Piers Watt Boulton, my executors, administrators, and assigns, or such others as I, the said Matthew Piers Watt Boulton, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "Improvements in Propulsion and in Aerial Locomotion, and in Apparatus connected therewith, Parts of which are applicable to Projectiles and to Boilers," upon the condition (amongst others) that I, the said Matthew Piers Watt Boulton, my executors, or administrators, by an instrument in writing under my, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

NOW KNOW YE, that I, the said Matthew Piers Watt Boulton, do hereby declare the nature of my said Invention, and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This Invention relates to propulsion more particularly to that of vessels and bodies moving through the air, to the generation of the motive force employed and to the construction of boilers to be used in aerial locomotion, some of these boilers being applicable to general purposes. It has for its objects to obtain and apply motive power for propulsion without the weight of engines or heavy moving mechanism, to provide security, and to obtain lightness of construction. It would be very advantageous to employ the motive power of aeriform jets for the propulsion of aerial vessels if this could be done without excessive loss of power, as in such a mode of propulsion the weight of engines and heavy moving mechanism is depensed with. But if the simple issue of the jet, as in a rocket, is used for this purpose, the loss of power is excessive. In order to employ the power more efficiently I adopt the following construction:—I cause the jet to issue towards the hinder part of the vessel from an orifice contained in a body so shaped as to offer little resistance to the passage of air. The hinder part of this body near the issue of the jet is a solid of revolution hollowed out or of concave section. The jet issues into a tube or passage communicating freely with the air, so that the jet causes a current of air to flow through it from front to stern. This passage is trumpet mouthed in front and is a central cavity in a body which is a solid of revolution tapering from front to stern, being hollowed out or having a concave section at the stern. The action of the current of air drawn or caused to move by the jet through the passage produces reduction of pressure on the front of the body in which the passage is situated, while this reduction does not take place behind it, and thus unbalanced pressure is produced urging the body forwards. This propulsive effect is added to that of the original jet. Cylindrical guides of successively larger size may be employed to guide the air to the jet so as to divide it into currents of different velocities. Instead of employing only one passage and body as previously described successive bodies and passages of successively increasing size may be used. In such a case the curvature of the lateral openings is varied to suit the different velocities of the inflowing currents, the amount of this curvature being in each case greater as the body is nearer to the jet and the velocity of inflow greater.

Another mode of employing the jet is as follows:—A body and passage having a form similar to that previously described is provided and the jet is caused to issue from an annular orifice within the passage so as to flow over its interior surface, and to cause a current of air through it, which acts by reduction of pressure in front in the manner already described. In this, as in the preceding case, guides may be employed dividing the air into currents of different velocities. Again, an annular jet may be caused to issue so that air has free access both to its exterior and interior, and thus the two modes above described may be combined, the current of air set in motion by the jet flowing through a passage in a body such as previously described. Instead of an annular jet or number of separate jets disposed circularly may be employed.

The following is another mode of employing a jet so as to produce propulsive effect:—A body is provided having the form of a solid of revolution tapered at the stern and prow or front. An annular jet of aeriform fluid is caused to issue at its fore part in front of its convexity so as to mix with air and create a mixed stream which flows or sweeps over the convex surface, finally quitting it backwards. In this case the action of the jet causes reduction of pressure on the front and thus produces propulsive effect. Jets may be employed to act in a similar manner on the curved surfaces of bodies which are not solids of revolution, such for instance as the sides of marine vessels or portions thereof. Many jets or combinations of them may be employed, and they may be so disposed and regulated as to vary the velocity, direction, and balance of the vessel.

Liquid jets moving in liquids may be treated in a manner similar to that above described.

The action of jets employed as above explained may be used for general purposes of propulsion, but it is peculiarly suited for aërial locomotion, as in this case the loss of power attending it is compensated by reduction of weight, which for such a purpose is a matter of primary importance.

Again, jets acting as above explained may be employed for propelling projectiles.

Apparatus as above described may be employed to propel aerial vessels containing light or heated gases. It may also be employed to propel an inclined plane or surface, by the motion of which through the air upward pressure is produced and the vessel supported in the manner which is well understood and has often been described. Upward support may also be obtained by causing a current or currents produced by jets or by motive power of other kinds generated in the propelled body to impinge on a suitably inclined plane or surface, or on several such surfaces suitably disposed. Currents may be employed which have previously produced propulsive effect. The velocity of the currents thus employed may greatly exceed the forward velocity of the vessel, so that the surface on which they impinge is acted on more forcibly. The same surface may be acted on both by the currents of high velocity and also by the pressure caused by the forward movement of the vessel. The surface or surfaces may also be acted on by the wind producing propulsive effect as in the case of birds. I prefer to give a curved form to the surface thus acted on so that the fluid shall impinge upon it without shock, and be continually deflected while passing in contact with it. A curved surface may be acted on by a current or currents so that both the actions previously described may be exerted on it simultaneously, that is to say, an upward pressure producing support and a propulsive action propelling in the direction required. The inclination and position of the surfaces may be altered so as to vary the amount and direction of the pressure and thus to change the course or balance the vessel. This mode of obtaining support for aerial vessels may be used whatever be the motive power employed to produce the aeriform current caused to impinge on the plane or surface.

Another mode of obtaining support is to cause the current produced by the action of the jets or other motive power to pass over the upper side of a plane or extended surface so that pressure is produced on its upper side. When the aerial vessel is supported by the buoyancy of gas a similar method may be employed for raising and lowering it. Also the different methods of obtaining support or counteracting gravity may be used in conjunction. When aerial vessels are thus supported they may under certain circumstances be guided by attaching to them a keel or keels moving through the sea so as to resist the action of a side wind and enable the vessel to be steered in the course desired. When it is not desired to use this action the vessel may move at an altitude above the sea. Such a vessel may carry an apparatus for generating gas to replace loss by leakage. Vapour or products of combustion discharged after performing work, or these mixed with air may be used for this purpose while the propelling power is in action.

The jets employed in the apparatus previously described may be jets of steam or of products of combustion, or of these mixed with steam, and may be generated in various ways. The following are methods which may be employed for this purpose :—Substances which do not require a supply of air for combustion, such as compounds of nitre with carbonaceous matter are introduced by a feeding apparatus into a vessel in which combustion is maintained. They are introduced into a cool part of the vessel and subsequently moved to the hot part, where the combustion goes on.

Another method of generating aeriform fluid is as follows :—Two substances which when mingled are capable of producing combustion without a supply of air, such for instance as nitre and carbonaceous matter, are introduced separately by feeding apparatus into a vessel in which combustion is going on, and by the supply of ingredients thus furnished the combustion is maintained. Liquids for this purpose may be fed from a pump. As examples of such liquids may be mentioned oils to supply carbon and hydrogen and nitric and chloric acid to supply oxygen and chlorine. The weight of water for the generation of steam and the weight of substances for supplying oxygen are both objectionable for the purpose of aerial navigation. In these respects there is advantage in using for the motive power inflammable gas or vapor mixed with air, as in this case the weight both of the oxygen and of the water is dispensed with.

In using this motive power for the production of jets one mode of proceeding is as follows :—Inflammable gas or vapor is produced at high pressure by heating in a boiler a hydrocarbon or other suitable substance, and the aeriform fluid produced issues constantly in a jet from an orifice, this jet acting in an apparatus such as previously described, and creating a current of inflammable vapor mixed with air. This mixture is ignited, the expansion of the current thus caused increasing its energy and propulsive effect. The heated current may be treated for the production of propulsive or useful effect as previously explained. A portion of its heat may be used to generate the inflammable gas or fluid. I prefer to employ liquids which vaporize without any solid residue. Also such as are converted into gas or vapor of high density as these at a given pressure produce a jet of lower velocity and consequently of greater propulsive efficiency.

In the methods above described the jet flows continously, in the one which I proceed to describe it acts intermittently. A jet of inflammable fluid draws air into a tube or chamber, filling this with an inflammable aeriform mixture The tube or chamber is furnished in front with a valve opening inwards so that when pressure is created within the tube the valve closes, while when the pressure is removed the valve opens and the inflammable fluid and air freely enter and flow along the tube. The motion of this valve also regulates the issue of the inflammable fluid from the vessel supplying it so that the closure of the valve stops its issue, while its opening allows it to take place freely. The hinder part of the tube is furnished with a valve which opens when there is no pressure in the tube so as to allow the free passage of a current through it, while when pressure is created in the tube this valve prevents exit of the fluid except by a small orifice through which it issues with high velocity as a jet.

The action of the apparatus is as follows:—The tube or chamber being filled with non-inflammable fluid and the valves at both ends being open, the inflammable fluid and air enter from the front, driving out the non-inflammable fluid and replacing it with an inflammable mixture. When the inflammable fluid has reached the end of the tube on a point near it it comes in contact with a flame kept constantly burning and is ignited by it. The pressure thus produced inside the tube closes the valves at both ends and thereby stops the flow of the air and of the jet while the orifice in the hinder valve remains open, and the products of combustion are forced by the pressure to issue through this as a jet with high velocity; this jet is treated as previously explained so as to produce propulsive or useful effect. When by the issue of the products of combustion the pressure within the tube is removed the valves at both ends of it open, the inflammable mixture enters at the front, driving out the products of combustion, and the operation is repeated. Many tubes may be employed with jets acting simultaneously and many jets may be employed acting at different times, so that a continuous propulsive effect is exerted. The action in this apparatus is not so simple as when the jets act continuously. The object aimed at in this method is that the heat may be applied to the fluid at high pressure and thus be employed more efficiently. It is also to be observed that in this plan the inflammable fluid is not generated at high pressure, and thus the boiler or generator may be light. A portion of the heat produced by the combustion may be utilized for generating the inflammable vapor or fluid.

In order to generate vapor of oils or hydrocarbons at high pressure for aerial propulsion I prefer to employ the following construction of boiler:—Two vessels are employed, an upper and an under one, connected by numerous vertical tubes, round the exterior of which the flame plays while the vapor is generated within them. Circulation of the liquid is maintained by means of a pump or forcing apparatus. By the action of this the liquid is raised into a chamber or passage in the upper vessel, whence it constantly descends in small streams on the surface of the tube plate which forms its bottom, or on plates or surfaces a little above it, and thence flows constantly downwards over the interior surfaces of the tubes and keeps these covered by a thin stream or film of liquid. The liquid thus flowing along the tubes is exposed to heat and gives off vapor which rises through the central parts of the tubes. By such a construction difficulties arising from the viscidity of the oil or liquid employed are obviated.

If steam is used for aerial propulsion a similar construction of boiler may be used, being light and compact and charged with a small weight of water.

The following is another form of boiler constructed with the view of securing lightness:—A cylindrical boiler is fitted with numerous tubular flues like the barrel of a locomotive engine. Opposite to the mouth of each of the tubular flues is the orifice of a tube communicating with a chamber containing inflammable fluid which issues from each of the orifices in a jet. The chamber is perforated with numerous tubes or passages allowing a free flow of air through them. Each jet draws or forces air along with it into the tubular flue of the boiler opposite to it. In order to secure a more complete mixture of air with it intermediate tubes may be placed between the jet orifices and the boiler tubes. The action of each jet creates an inflammable mixture in the tubular flue opposite to it, which is ignited and passes through that flue giving out heat to the liquid in the boiler. The jets which create this effect may be of various kinds, such as jets of inflammable gas or vapor, or jets of steam or of air carrying along with them inflammable liquids in the form of spray or solids in the form of dust, as have been used in other constructions. In this construction the products of combustion act on the extended surface afforded by the numerous tubular flues at their highest temperature and thus compactness and lightness of boiler are obtained. The boilers may be fitted with diaphragms both longitudinal and transverse to secure more rapid circulation of the liquid. Part of the heat of the fluid passing through the tubes may be used to generate the inflammable gas or vapor which may be employed in the jets. Boilers constructed as thus described may be used for various purposes, as for instance, for marine and locomotive engines. For the safety of aerial vessels it is important to provide a controlling power not only to direct their horizontal and vertical course, but also to prevent their turning over by rotating on the longitudinal axis. A certain stability of the kind desired is afforded by using an extended surface whose sides make an angle from the axis upwards as has previously been described by others. But it is desirable to provide a more powerful action preventing rotation of the body in this direction. For this purpose a rudder of the following construction may be adopted:—Vanes or moveable surfaces are attached to arms projecting from the vessel laterally or at right angles to its length. When these vanes are not required to act they present their edges to the front, so as to offer little resistance to the vessel's movement, but if the vessel should begin to rotate on the longitudinal axis the vanes are moved so as to take inclined positions, those on the ascending side of the vessel being caused to rotate to such an inclination that the air impinging upon them exerts a pressure downwards, while those on the descending side are so inclined that the air impinging upon them exerts a pressure upwards, thus the balance of the vessel is redressed and its further rotation prevented. The vanes may be moved by hand or by self-acting mechanism; for this purpose a weight or heavy body is connected to the vessel which carries the vanes so that the vessel may rotate on the longitudinal axis without imparting such rotation to the weight or heavy body. When rotation of the vessel in the direction described begins the relative positions of the vessel and the heavy body change, and consequently by means of cords or other suitable connections between the heavy body and the vanes the required movement can be communicated to the vanes.

Stability of the kind desired may also be obtained by attaching to the upper side of the aerial vessel receptacles rendered buoyant by light or heated gases which may be replenished from time to time; these receptacles may be of small content, so shaped as to offer little resistance to the air.

Valves acted on by self-acting mechanism of a kind similar to that above described may also be used when desired for keeping the vessel in a fixed course both vertically and horizontally.

Description of the Drawings.

Figure 1 is a longitudinal section of a body or vessel constructed according to my Invention, propelled by an annular jet issuing at its front. *a* is the body or vessel containing fluid under pressure and shaped so as to offer little resistance to longitudinal movement in the direction of the arrow *e*; *b* is a tapering front or prow connected to *a* by thin ribs; and *c* is a cavity so formed with an opening round its periphery that an annular jet of fluid can issue by it perpendicularly to the longitudinal axis of *a* or nearly so. When the jet so issues it tends to reduce pressure on all sides. By virtue of this reduction of pressure the air (or other medium in which the body is placed) in front being free to move flows backwards towards the jet and mingles with it, while the body *a* being also free to move, moves forwards in the direction of the arrow *e*. The jet instead of issuing from *c* perpendicularly to the longitudinal axis of *a* may be made to issue at any desired angle by suitably forming the passage round the periphery of *c*.

Figure 2 is a longitudinal section of an apparatus constructed according to my Invention, whereby a jet of inflammable aeriform fluid is mingled with air, and the mixture being ignited a jet of greater energy is caused to issue so as to give propulsive effect. *a* is a tube conveying the jet of inflammable aeriform fluid from any vessel in which it may be generated or contained; *b* is a vessel attached by ribs to the tube *a*; *c* is a valve fixed on a stern fitted to slide longitudinally in a boss attached to the interior of the vessel *b* by means of cross ribs *k*. This valve has two faces, the one of them *c* to fit the interior of the mouth of the vessel *b*, and the other face *d* to fit the mouth of the tube *a*, so that when the valve is moved forward, it closes the mouths of *a* and *b* simultaneously; *e* is another valve formed with a passage or channel through it opening for the issue of a jet at *f*. This valve *e* is mounted on a stem fitted to slide longitudinally in a boss supported by ribs *g*, and their stern is fitted with a spiral spring *h* which keeps the valve *e* away from the mouth of the vessel *b* to which it is fitted unless when the fluid pressure in the interior of *b* is sufficient to overcome the force of the spring in which case the valve *e* closes the mouth of *b*; the action of this apparatus is as follows:—The valves being in the position represented in the Drawing a jet of inflamable aeriform fluid issuing from *a* enters the vessel *b* drawing air with it through the passage left open by the valve *e* and expelling the contents of the vessel *b* by the channel *f* and the passage round the valve *e* as indicated by the arrows; when the vessel *b* has been thus charged with an inflamable aeriform mixture it is ignited and the expansion produced by the ignition raises the pressure within the vessel *b*. This pressure causes the valve *e* to close, thereby preventing the issue of any of the fluid at that mouth of the vessel, and also closing the jet tube *a* so as to prevent the issue of inflammable fluid from it, at the same time the valve *e* is closed and the products of combustion issue only in a jet by the channel *f* giving a propulsive effect in the direction opposite to that of their issue. When so much of these products of combustion have thus issued as to reduce the pressure within *b* to nearly that of the atmosphere, the spring *h* causes the valve *e* to open and the pressure in the tube *a* opens the valve *e*, the action is thus repeated and goes on continuously in a similar manner.

Figure 3 represents a section of part of a boiler constructed according to my Invention for generating vapour of oils or hydrocarbons. *a* is a lower chamber or vessel containing the liquid to be vaporized, and *z* is an upper chamber or vessel connected with *a* by numerous tubes *c, c*. The flame of the furnace plays round the exterior of the tubes *c, c*. *d* is a pump which draws liquid from the lower chamber *a* and forces it through a pipe *e* which enters the upper chamber *z* and extends along it, having numerous holes *f, f*, along its under side. When the pump is worked liquid is discharged through its holes *f, f*, upon the surface of the tube plate which forms the bottom of the chamber *z* and it overflows down the interior surfaces of the tubes *c*, keeping them covered by a thin stream or film of liquid, and giving off vapour during its descent. The vapour so given off rises through the middle parts of the tubes into the chamber *z*, and such of the liquid as may reach the chamber *a* without being vaporised in its descent is again caused to circulate by the action of the pump.

Figure 4 represents a section of part of a tubular boiler constructed according to my Invention, in which a separate flame is provided for each tube. *a, a*, are the tubes surrounded by liquid, as usual; *b* is a vessel supplied with inflamable gas or vapour; *c, c,* are nozzles through which the inflamable gas or vapour issues from *b* in jets; *d, d,* are trumpet-mouthed air tubes fixed axial with the nozzles *c, c*; these nozzles and the air tubes are fixed axial with the boiler tubes *a, a.* *e, e,* are tubes for the passage of air through the vessel *b.* When jets issue from the nozzles *c, c,* air being freely supplied to the space round them from the air outside the vessel *b* and by the tubes *e, e,* which penetrate that vessel, is caused to flow with the jets through the pipes *d, d,* and to mingle with the inflammable matter. The mixture issuing from the pipes *d, d,* being ignited a flame is thus caused to pass along each of the tubes *a, a.* The air pipes *d, d,* being placed at a little distance from the mouths of the tubes *a, a,* an additional quantity of air such as may be necessary for complete combustion is drawn in by the current issuing from these pipes and mingles with them in the tubes. The vessel *b* and the air pipes *d, d,* being mounted in one frame can be set at a greater or less distance from the mouths of the tubes *a,* and thus the quantity of air entering these tubes along with the ignited currents can be adjusted as may be desired. The pipes *d, d,* instead of having the form represented in the Figure may be simple cylinders. Also they may be cylinders pierced with holes for the inflow of the air.

Figure 5 represents a transverse section of a plane fitted with rudders constructed according to my Invention to prevent its turning over on an axis in its line of motion through the air. *a* is a section of the plane which is supposed to have taken a position inclined to the horizon; *b* and *c* are two vanes mounted on axes one at each side of the plane, so that it can be turned round like a throttle valve; *d* is a heavy body suspended by an endless cord, which passing over guide pullies is wound for several times on barrels on the axes of *b* and *c.* When the plane takes an inclined position, as represented in the Figure, the weight *d* tending to hang vertically under the centre of gravity tightens the cord on one side and slackens it on the other, and thus causes the vanes *b* and *c* to turn into inclined positions upon their respective axes. The cord is so wound upon the barrels *b* and *c* that while the one is caused by the action of *d* to rotate in the one direction the other rotates in the opposite direction.

Figure 6 represents an end view of *b* and Figure 7 an end view of *c* when the vanes are turned to suit the oblique position of *a* in

Figure 5. The plane being moved through the air in the direction of the arrow *e* the air presses upon the under surface of the vane *c* and on the upper surface of *b*, and thus tends to restore the plane to its horizontal attitude.

In witness whereof, I, the said Matthew Piers Watt Boulton, have hereunto set my hand and seal, this Thirtieth day of July, in the year of our Lord One thousand eight hundred and sixty-eight.

M. P. W. BOULTON. (L.S.)

Witness,
H. MILES,
21, Cockspur Street,
Charing Cross.

LONDON:
Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1868.

A.D. 1868. FEB. 5. Nº 392.
BOULTON'S SPECIFICATION.

(1 SHEET)

FIG. 1.

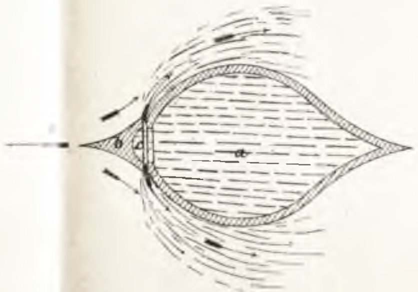


FIG. 2.

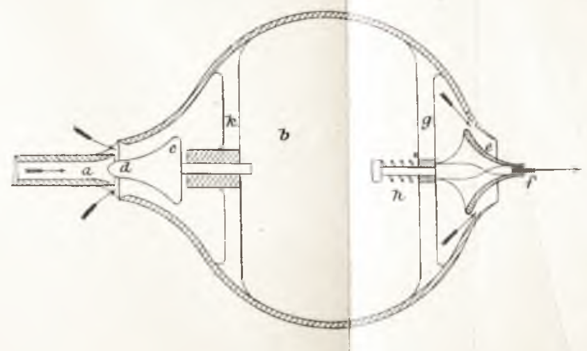


FIG. 3.

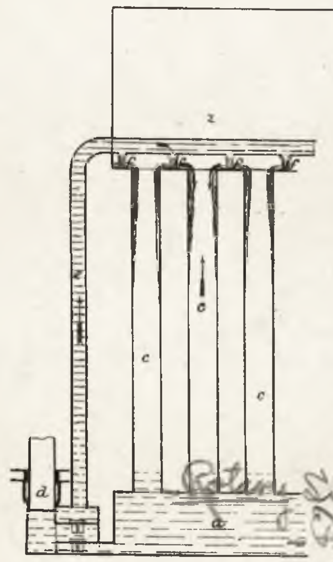


FIG. 4.

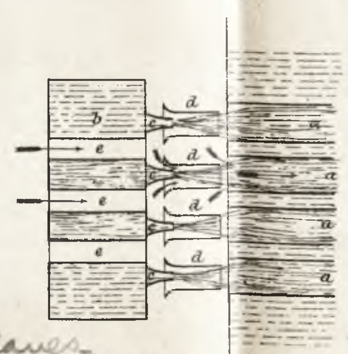


FIG. 5.

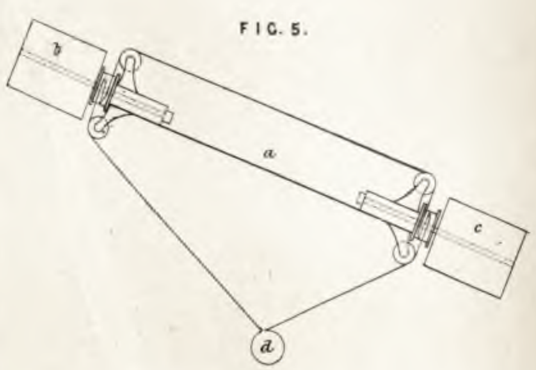


FIG. 6.

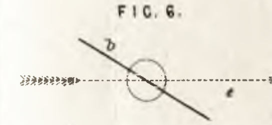
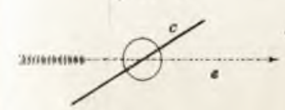


FIG. 7.



~~Rotary~~ Side planes–
–Flat to line flight–
–Right angles to plane. Our proof of model so shows, N. present.
–Says by hand, but don't say weight discarded.
–Weight would move to low side & capsize–
–C. photos show Curtiss–W. perfect.
not Boulton–

The filed drawing is not colored.

Drawn on Stone by Malby & Sons.

LONDON. Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE.
Printers to the Queen's most Excellent Majesty. 1868.

–No rud. shown or directly described.

A.D. 1842 . . . . N° 9478.

Locomotive Apparatus for the Air, Land, and Water.

HENSON'S SPECIFICATION.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, William Samuel Henson, of No. 26, New City Chambers, Bishopsgate Street, in the City of London, Engineer, send greeting.

WHEREAS Her present most Excellent Majesty Queen Victoria, by Her Royal Letters Patent under the Great Seal of Great Britain, bearing date at Westminster, the Twenty-ninth day of September, in the sixth year of Her reign, did, for Herself, Her heirs and successors, give and grant unto me, the said William Samuel Henson, Her especial licence, full power, sole privilege, and authority, that I, the said William Samuel Henson, my exors, admors, and assigns, or such others as I, the said William Samuel Henson, my exors, admors, or assigns, should at any time agree with, and no others, from time to time and at all times during the term of years therein expressed, should and lawfully might make, use, exercise, and vend, within England, Wales, and the Town of Berwick-upon-Tweed, and also in all Her said Majesty's Colonies and Plantations abroad, my Invention of "Certain Improvements in Locomotive Apparatus and Machinery for conveying Letters, Goods, and Passengers from Place to Place through the Air, part of which Improvements are applicable to Locomotive and other Machinery to be used on Water or on Land;" in which said Letters Patent is contained a proviso that I, the said William Samuel Henson, shall cause a particular description of the nature of my said Invention, and in what manner the same is to be performed, to be inrolled in Her said Majesty's High Court of Chancery within six calendar months next and immediately after the date of the said in part recited Letters Patent, as in and by the same, reference being thereunto had, will more fully and at large appear.

[*Price* 8*d*.]

NOW KNOW YE, that in compliance with the said proviso, I, the said William Samuel Henson, do hereby declare that the nature of my said Invention, and the manner in which the same is to be performed, are fully described and ascertained in and by the following statement thereof, reference being had to the Drawings hereunto annexed, and to the figures and letters marked thereon (that is to say) :—

The Invention relates, first, to the constructing of locomotive machinery and apparatus for conveying letters, goods, and passengers from place to place through the air; and, secondly, to improvements in constructing steam boilers for the generating of steam to give motion to locomotive machinery in the air, and also locomotive and other machinery used on water or on land; and in order that my Invention may be fully understood and readily carried into effect, I will proceed to describe the means pursued by me; and in order that the description hereafter given may be rendered clear, I will first shortly explain the principle on which the machine is constructed. If any light and flat or nearly flat article be projected or thrown edgewise in a slightly inclined position, the same will rise on the air till the force exerted is expended, when the article so thrown or projected will descend; and it will readily be conceived, that if the article so projected or thrown possessed in itself a continuous power or force equal to that used in throwing or projecting it, the article would continue to ascend so long as the forward part of the surface was upwards in respect to the hinder part, and that such article, when the power was stopped, or when the inclination was reversed, would descend by gravity only if the power was stopped, or by gravity aided by the force of the power contained in the article, if the power be continued, thus imitating the flight of a bird.

Now, the first part of my Invention consists of an apparatus so constructed as to offer a very extended surface or plane of a light yet strong construction, which will have the same relation to the general machine which the extended wings of a bird have to the body when a bird is skimming in the air; but in place of the movement or power for onward progress being obtained by movement of the extended surface or plane, as is the case with the wings of birds, I apply suitable paddle wheels or other proper mechanical propellers worked by a steam or other sufficiently light engine, and thus obtain the requisite power for onward movement to the plane or extended surface; and in order to give control as to the upward and downward direction of such a machine, I apply a tail to the extended surface, which is capable of being inclined or raised, so that when the power is acting to propel the machine, by inclining the tail upwards, the resistance offered by the air will cause the machine to rise on the air; and, on the contrary, when the inclination of the tail is reversed, the machine will immediately be propelled downwards, and pass through a plane more or less inclined to the horizon as the inclination of the tail is greater or less; and in order to guide the machine as to the lateral direction which it shall take, I apply a vertical rudder or second tail, and according as the same is inclined in one direction or the other, so will be the direction of the machine.

Having thus given the general principles on which the machinery and apparatus, according to the first part of my Invention, are constructed, I may remark, that it will be evident that the principal objects to be considered in the construction of such a locomotive machine are lightness with strength in respect to the machine itself, and lightness with respect to quantity of power offered by the engine employed; and I would here state, that although I shall hereafter describe a particular construction of machine and engine to be used in propelling the same, yet I do not confine myself to the details thereof, as variations may be made, so long as the general principle of construction be retained.

Description of the Drawings A.

Figure 1 represents a machine and apparatus constructed according to the first part of my Invention, the covering fabric being removed, in order that the manner of framing the parts together may be more readily traced. Figure 2 shows the same view of the machine, with the covering applied. Figure 3 shows an underside view of the machine, with the covering fabric in its place; the view shown by this Figure being one offered to the viewer when standing below the machine, and looking upwards; the other Figures of these Drawings showing separate parts, in order that the details of construction may be more fully understood than could be the case by simply examining the perspective Drawings of the machine shown at Figures 1, 2, and 3, and some of these details are shown on a larger scale than the same parts in the other Figures. Figure 4 is a side view of the main frame or extended surface, of which the machine is principally constructed. Figure 5 shows a plan of the tail for controlling the direction of the machine in its upward and downward direction. Figure 6 shows a side view of the same tail. Figure 7 shows one of the framed bars which run from front to back of the machine, which I prefer to be of wood or bamboo, in order that I may obtain lightness with sufficient strength. Figure 8 shows two sections of the hollow bars of wood, or other suitable material or materials for the bars, of which the main frame is composed. Figure 9 shows a plan and side view of the mode by which I fix and tighten the suspending wires and wire braces or rigging of the machine

On an examination of the Drawings it will be seen that the machine consists of an extended surface or plane extending on either side of a car or vessel, in which the engine, fuel, passengers, goods, and letters are carried, the nature of which vessel or car is more clearly shown in the plan and side section, Figures 10 and 11, which are on an enlarged scale when compared with the other Figures of these Drawings, such car or vessel being framed together with a view to strength and lightness; and the outline shows the position of a steam-boiler and engines for giving motion to the propelling machinery hereafter explained, such engine and boiler being fixed rather forward in the car or vessel, because from experiment I have found it desirable that the weight carried by such a description of locomotive machine should be forward; and it will be seen that the car or vessel has three wheels, in order that when the car comes to the earth it may run freely without injury, and owing to the great controul which the tails offer in governing such a machine in descending, the car may be caused to come to the earth in so flat an incline that in taking the earth very little, if any, shock will be perceived by the passengers. In the car two masts are fixed, which rise above the upper part of the car, as is shown, and from the upper parts of these masts the two surfaces or planes on either side of the car are suspended, and the framing of those surfaces or planes are braced to the lower ends of such masts; thus, in fact, making the whole machine as one trussed beam of very light construction, yet offering the requisite stiffness for its purpose. I have not thought it necessary to show the interior arrangement of the car, as the same will readily be fitted up according as it is more intended for passengers or for goods, or otherwise. The suspending of the framing is by numerous wires, which I prefer to be of an oval section, so as to offer as little resistance as possible in passing through the air, such wires proceeding in various directions, as is shown in the Drawings. A is the fore mast and B the hind-mast; from the upper parts of these masts descend suspending wires (1), (1), to the points (2), (2), of the lateral main bars C, D, on either side of the car, thus suspending those main bars C, D, from the masts; and there are other suspending wires (3), (3), which, proceeding from the upper parts of the masts, cross each other, and are made fast at the same points (2), (2), of the main bars C, D; and there are corresponding bracing wires proceeding from the lower ends of the masts to the same points (2), (2), of the main bars, as is shown; and there are also suspending wires (4), (4), descending from the mast B, and affixed to the hinder projecting frame E, E, which carries the tails of the machine. (5), (5), are suspending wires from the upper part of the foremast A to the front part of the car. (7) is a suspending wire affixed at the upper part of the fore-mast;

it is made fast to the hinder framing of the car. (8) is a similar suspending wire made fast to the upper part of the hind-mast B, and also to the fore part of the car ; and there is a wire brace (9) affixed to the upper part of each mast, and between the two masts above the car is stretched a sail, shown in Figure 2, which facilitates the lateral steering of the machine. (10), (10), are suspending wires from the masts to the sides of the car, and (11), (11), are braces to correspond with the suspending wires (10). At the points (2), (2), of the main bars C, D, on either side of the car, are uprights F, F, affixed to the main bars C, D. Ascending above and decending below those bars, and from the upper ends of these uprights, proceed suspending wires (12), (12), to the main bars C, D, near the sides of the car; and there are corresponding wire braces (13), (13), from the lower ends of the uprights to the main bars near the car, as is shown. From the upper and lower ends of the uprights also proceed other suspending bracing wires (14), (15), which are respectively made fast at the points (16), (17), of the main bars C, D ; and there corresponding brace wires proceeding from the points (16), (17), to the lower ends of the uprights F, as are shown in the Drawings; and it will be seen that the two uprights F, on either side of the car, are braced together by diagonal brace wires (18), (18) ; the object of all which suspending and brace wires is to obtain great stiffness and strength with lightness of structure. G is the central main bar, and it will be seen that the main bars, C, D, G, are fixed together by means of the end pieces H, H ; and it will be understood that the main bars C, D, are made hollow in order to obtain lightness and stiffness, and the main bar G is shown to be a plate of wood on edge. In the front of the projecting planes, on either side of the car, there is fixed the front bar I ; and it will be seen that the bars C, D, G, and I, are combined into one framing with the car by means of the framed beams or bars H, J, K, and the whole of the under and upper surfaces of the projecting planes are to be covered with a strong close fabric. I prefer strong oiled silk for this purpose ; and such coverings are affixed to light frames similar to the framed beams J, K, at the points (19), (19), which are capable of sliding to and fro on the main bars C, D, and G, the parts of the covering fabrics being fixed to the main framing at the beams H, J, K. Thus the portion of the covering from the outer end of either side plane can be slided from the beam or bar K to the outer, and the next portion of the covering can be slided back from the beam or framed bar J to the framed bar K, and the next part of the covering can be slided back to the framed bar or beam J ; and this is accomplished by means of cords N from the windlass L, in the fore part of the car, which cords pass over the pulley M, M, the cords being suitably connected with the sliding frames to which the covering fabrics are affixed, the object being that the coverings may be drawn up when the machine is not in use. The tail which governs the machine in its upward and downward movements is affixed to the axis O, the ends of which move in bearings at O', and the tail is suspended from the upright P, which is also affixed to the axis O; this tail consisting of three bars, Q, Q, Q, and the smaller bars Q^1, which are all affixed to the axis O, which bars are covered with a suitable fabric, and I prefer strong oiled silk for such purpose. These bars are capable of being separated or opened out by means of the cords R, R, passing partly round pulley R^1 to the car, where they are made fast; and the bars Q are capable of being drawn together by the cords S, S, which pass partly round pulleys S^1, and thence go to the car, where they are made fast. The requisite up-and-down motion is communicated to this tail by means of the cord T, which is made fast at either end of the upright P. It then passes partly around the pulleys V at the upper and lower ends of the hind-mast B; the cord then takes several turns around the windlass or barrel U, which is worked by any convenient means, which I have not thought it necessary to show, as the same will readily be applied by a mechanic; and according as the windlass or barrel U is turned in one direction or the other, so will be the inclination of the tail, and such inclination will be more or less upwards or downwards, according to the directions desired to be obtained to the machine. I have not thought it necessary to enter into every detail of the means of framing and connecting the parts together, as these parts of the construction will readily be performed by proper workmen, taking care that all parts are well and strongly joined. I would here observe that a machine constructed as I have above described may have propellers of various constructions applied thereto, but I believe paddle wheels with oblique paddles will be most suitable for the purpose. I will therefore now describe the application of such paddle wheels, and the best means I am acquainted with for giving motion thereto. W, W, are two paddle wheels, their shafts or axes turning in bearings carried by the main bar D and the bar X, as is shown; the paddles of these paddle wheels being set at about an angle of 45°, to their respective axes of motion, and to the axes of these wheels are affixed the pulleys W^1, which receive the endless band or cord Y, which receive its motion from the steam or other proper engine carried by the car; and although I do not confine myself to the use of any particular construction of engine for such purpose, I will hereafter explain the best construction of steam-engine I am acquainted with for the purpose of giving motion to suitable propellers for a locomotive engine constructed according to the first part of my Invention. Z is the lateral steering tail or rudder, which consists of a triangular frame covered with fabric, as before explained in respect to the other parts; this rudder is hung on the upright P, and is caused to move in either direction by means of cords passing into the car, such cords being affixed to the ends of the bar Z^1. In starting the machine, I prefer to do so from an inclined plane or the side of a hill, and I allow the machine to run forward down the incline, the propellers being first set in motion, when it will be found that in a short time they will act sufficiently upon the air to cause the machine to leave the incline and proceed in any desired direction. In constructing the machine above described the following are the best proportions which I am enabled to lay down from the various experiments which I have been enabled to make; at the same time, I do not confine myself thereto:—There should be about one square foot for each half pound weight of the machine, including machinery, fuel, and load; and the following are the dimensions of the machine I am making, and which will weigh about three thousand pounds. The surface of the planes on either side of the car will measure four thousand five hundred square feet, and the tail one thousand five hundred more, with a steam-engine (high pressure) of twenty-five to thirty horse power.

Having thus described the nature of a locomotive machine constructed according to the first part of my Invention, I will proceed to explain a steam-engine shown in Drawing B, which I have arranged for giving motion to suitable propellers, and I will also describe my improved construction of steam boiler for supplying such or other construction of steam-engine with steam, which improved construction of steam boiler constitutes the second part of my Invention. Figure 12 represents a front view of a steam-engine constructed suitably for giving motion to the propellers of a locomotive machine such as is above described. Figure 13 shews a side view thereof, and the Drawing also shows the steam-engine in connexion with a steam boiler, the peculiar construction of which constitutes the second part of my Invention, Figure 13 showing a side section of such boiler. Figure 14 shows a front section thereof. Figure 15 shows a plan of the boiler in section, taken just above the fire bars; and Figure 16 shows a plan in section, taken at the upper part just above the series of conical vessels of which the boiler is composed. The other separate views show the description of steam cocks used for admitting the steam to flow from the boiler into the steam cylinders, and from the steam cylinders into the atmosphere. *a, a*, are the steam cylinders, each cylinder having four steam cocks *b,b*, and two *c, c*, two (*b,b*,) for admitting steam into the steam cylinders, and two (*c, c*,) for permitting the steam to escape into the atmosphere. *d, d*, are the steam pipes from the boiler to the steam cylinders; and *e, e*, are the eduction steam pipes from the steam cylinders; *f*, *f*, are the piston rods, the cross heads of which are guided by the rods *g*, *g*; to the cross heads are attached the connecting rods *h*, *h*, which give motion to the cranks *i*, *i*, affixed on the main or driving shaft *j*, on which there is a suitable drum or pully *k*, for giving motion to a suitable band or cord for driving the propellers, as shown in the Drawings. *l*, *l*, *m*, are rods worked by excentrics for giving motion to the plugs of the steam cocks for admitting the steam into and from the steam cylinders; and *n*, *n*, are pump rods for pumping water into the boiler. *oo*, are two uprights or pillars between the engines and the bearings of the main shaft. The boiler consists of a peculiar arrangement of a series of conical vessels, *p*, *p*, *p*, and *q*, *q*, *q*. The conical vessels *p*, *p*, *p*, are affixed at the lower ends into water pipes *r*, *r*, *r*, thus dividing the boiler into two compartments, each of which has its grate of fire bars, as is shown, and the vessels *p*, *p*, are connected to the vessel *q*, *q*, by means of short pipes p^1. The upper ends of the conical vessels *p*, *p*, enter into and are affixed to the cylindrical vessels *s*, *s*, and *t*, the three vessels *s*, *s*, and *t*, being connected together, as is shown. The conical vessels *q*, *q*, are short vessels which are affixed to and enter into the vessels *s*, *s*, and *t*, as is shewn. The steam passes off at the valve *v* to the steam pipe, and the quantity passing away from the boiler may be regulated at pleasure by the valve. The boiler is enclosed in the case *u*, *u*, as is shown, in which are found openings for the fire doors and ash-pit doors, *w*, *w*, being the flues which convey off the products of combustion to the chimney. The object of this arrangement of boiler is to obtain great strength with lightness, at the same time extensive heating surfaces, in order to obtain the greatest power in the least space. I prefer to construct such steam boiler of copper, the screw joints being of brass, but I do not confine myself thereto. It will be evident that by thus combining a series of conical vessels *p*, *p*, *p*, and *q*, *q*, *q*, with the pipes *r* and the vessels *s*, *s*, and *t*, a very simple construction of boiler will be obtained, and owing to the larger parts of the conical vessels being upwards the heat of the furnace will be most advantageously applied. I would remark, in respect to this part of my Invention, that I do not confine myself to the precise details shown, provided the peculiar combination of conical vessels with the other parts as above described be retained.

Having thus described the nature of my Invention, and the best means I am acquainted with for performing the same, I would have it understood that what I claim is,—

First, the mode of constructing locomotive apparatus and machinery for conveying passengers, goods, and letters through the air as above described.

And, secondly, I claim the mode herein explained of constructing steam boilers applicable to locomotive machinery, such as above described, and also engines used on land or water.

In witness whereof, I, the said William Samuel Henson, have hereunto set my hand and seal, this Twenty-eighth day of March, in the year of our Lord One Thousand eight hundred and forty-three.

WILLIAM SAMUEL (L.S.) HENSON.

AND BE IT REMEMBERED, that on the Twenty-eighth day of March in the year of our Lord 1843, the aforesaid William Samuel Henson came before our said Lady the Queen in Her Chancery, and acknowledged the Specification aforesaid, and all and everything therein contained and specified, in form above written. And also the Specification aforesaid was stamped according to the tenor of the Statute made for that purpose.

RICHARDS.

Enrolled the Twenty-ninth day of March, in the year of our Lord One thousand eight hundred and forty-three.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.
[Wt. 57—50/11/1910.]

A.D. 1842. Sep. 29. No. 9478.
HENSON'S SPECIFICATION
3rd Edition

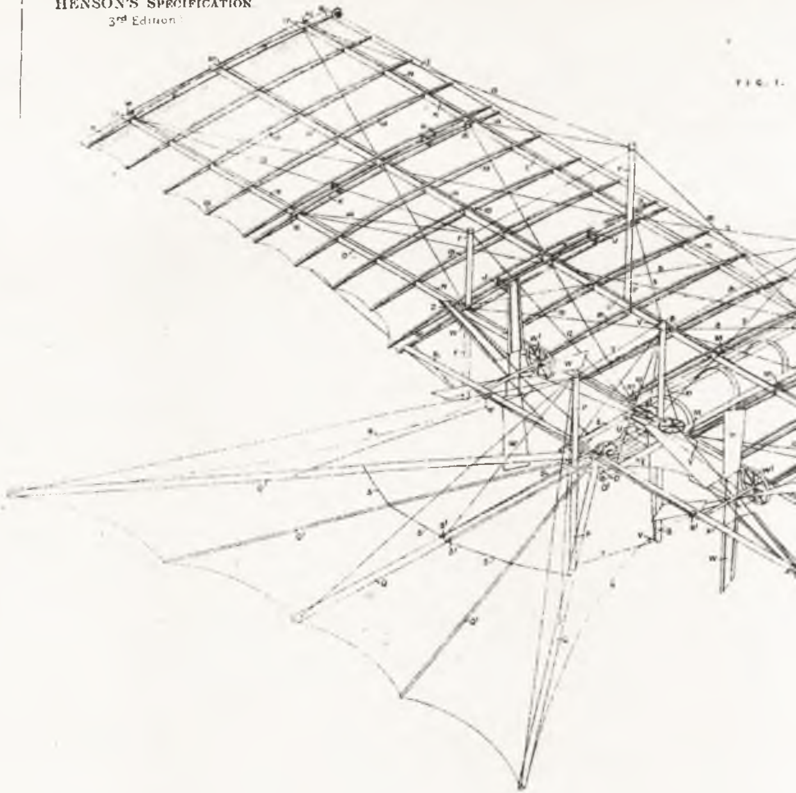
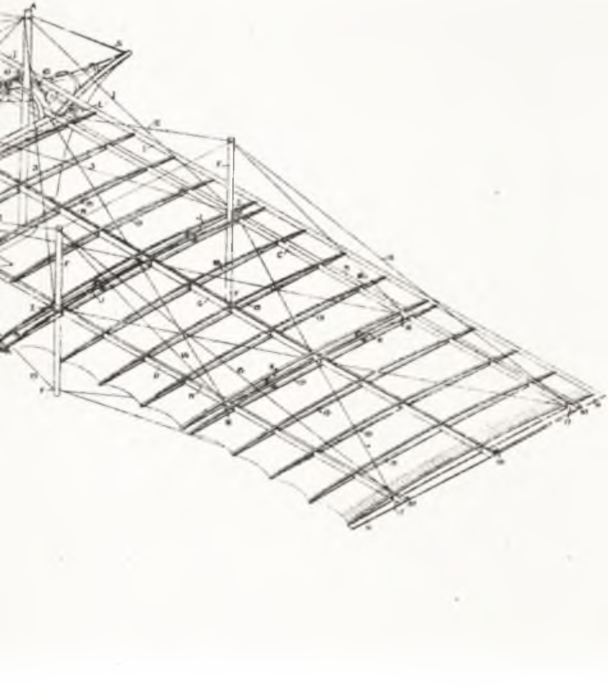


FIG. 1.

2014

6 SHEETS
SHEET 1
Drawing A



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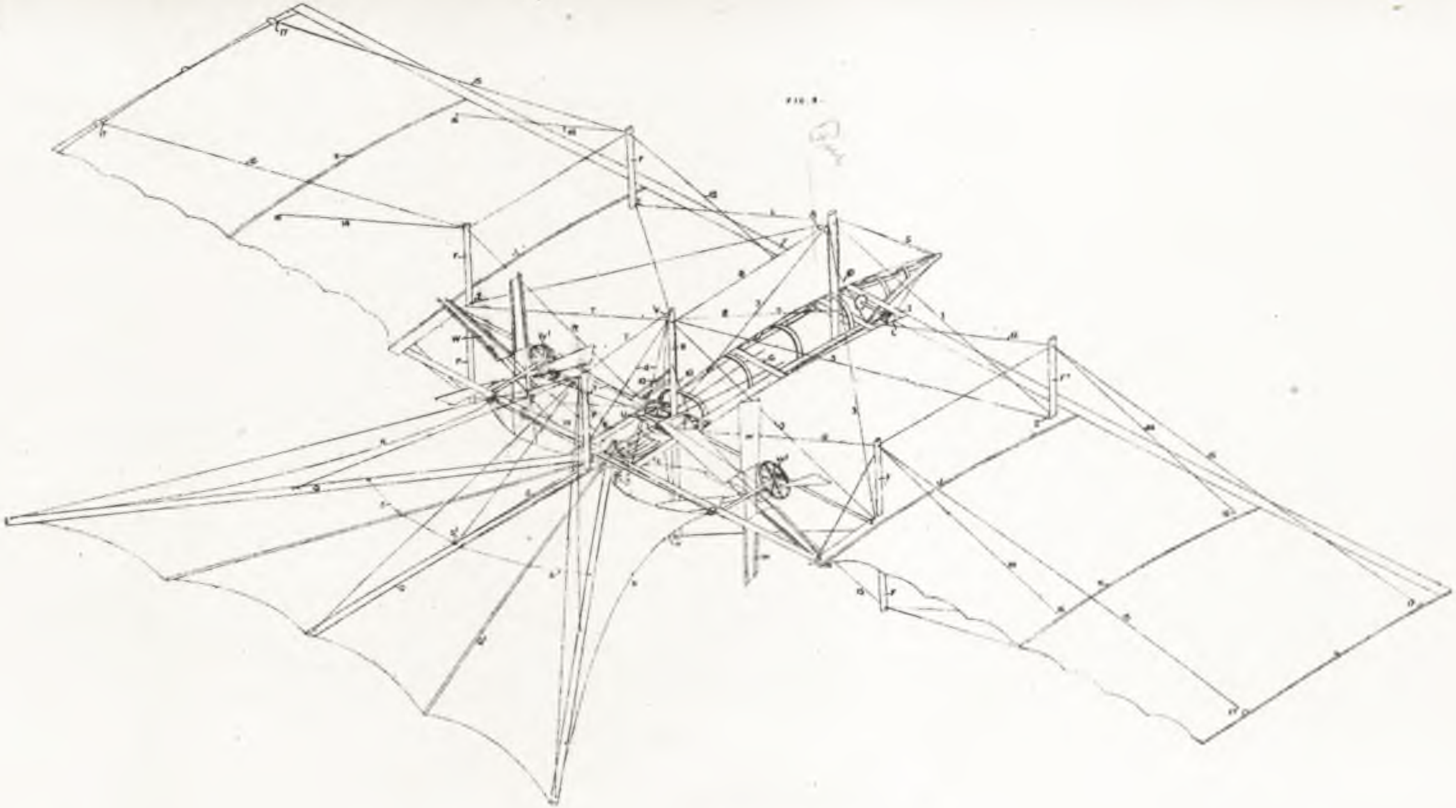
(6 SHEETS)
SHEET 2.
DRAWING A.



2015

2016

FIG. 3

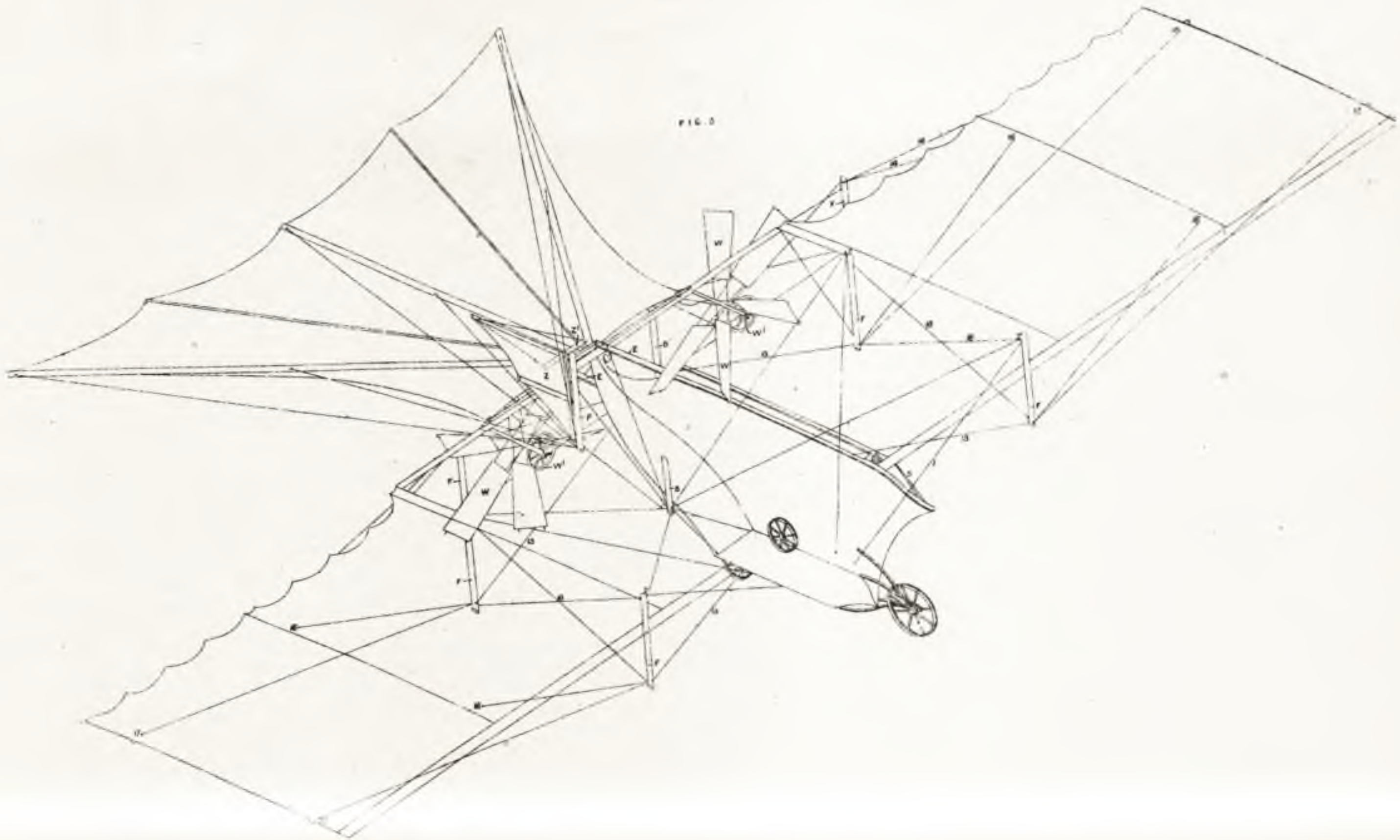


FIG. 4.

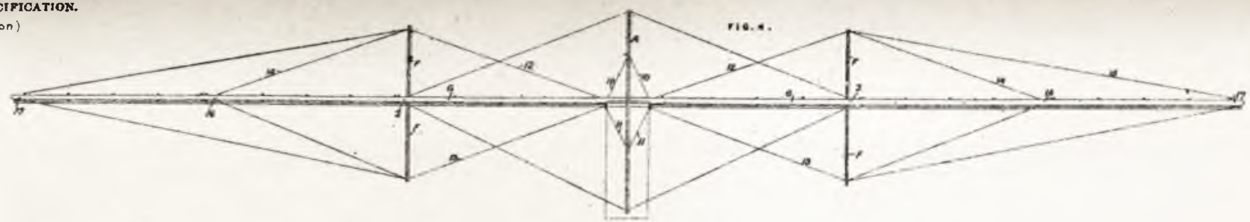


FIG. 7.

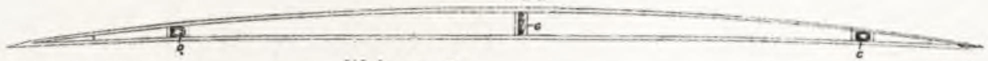


FIG. 6.

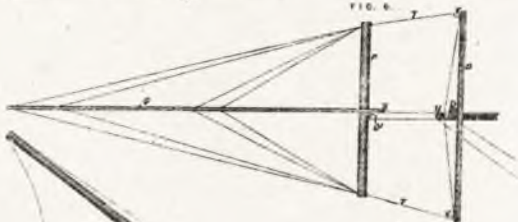


FIG. 5.

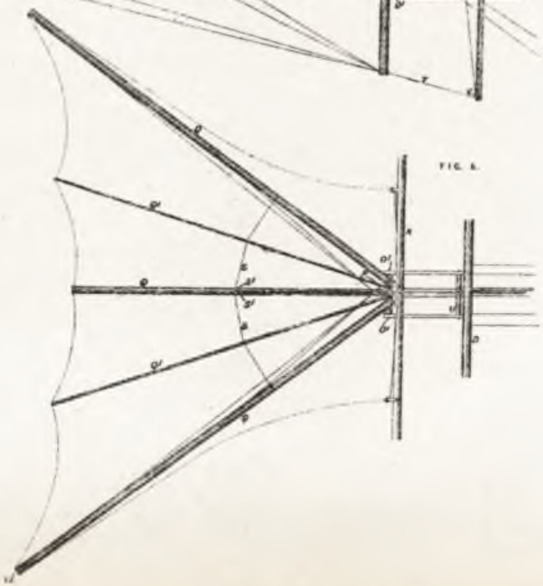
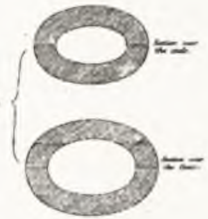


FIG. 8.



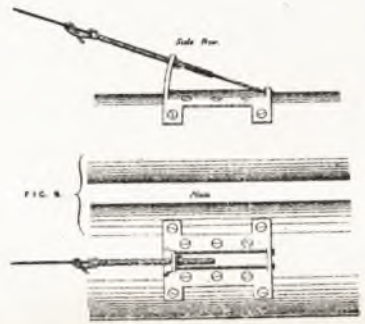
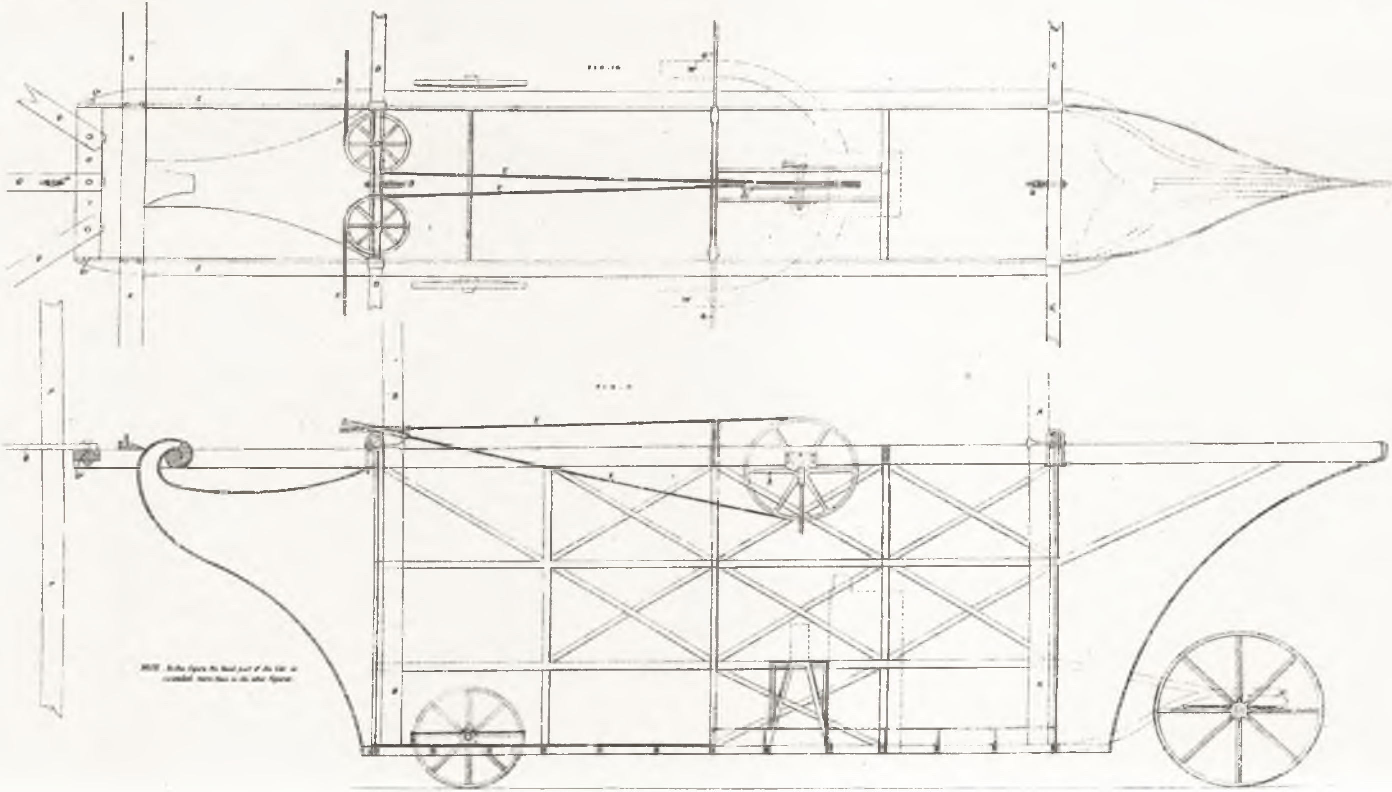


FIG. 9.

2017

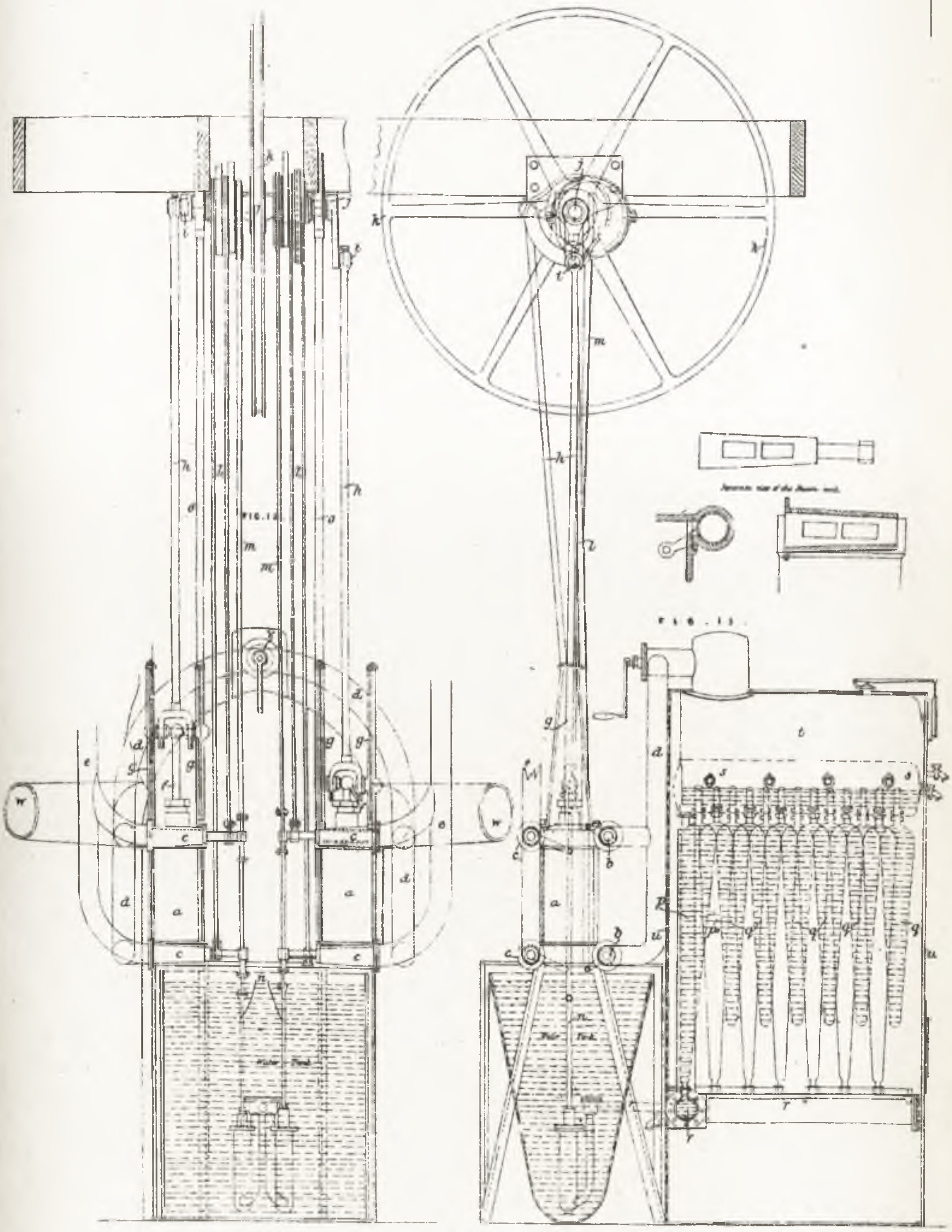
A.D. 1842. Sep 29. No 9478.
HENSON'S SPECIFICATION.

Drawing A.



A.D. 1842. Sep. 29. No. 9478.
HENSON'S Specification.
1st Edition

6 SHEETS
SHEET 6
Part I



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HENSON'S SPECIFICATION.
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FIG. 15.

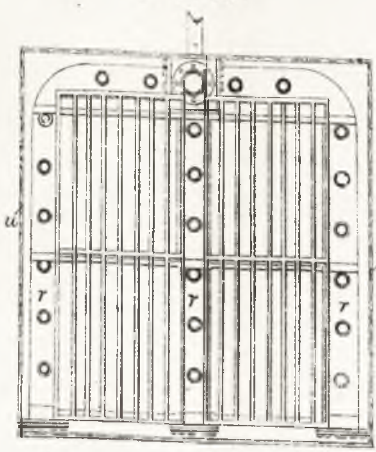


FIG. 16

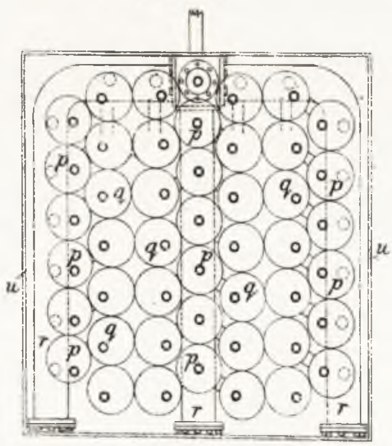
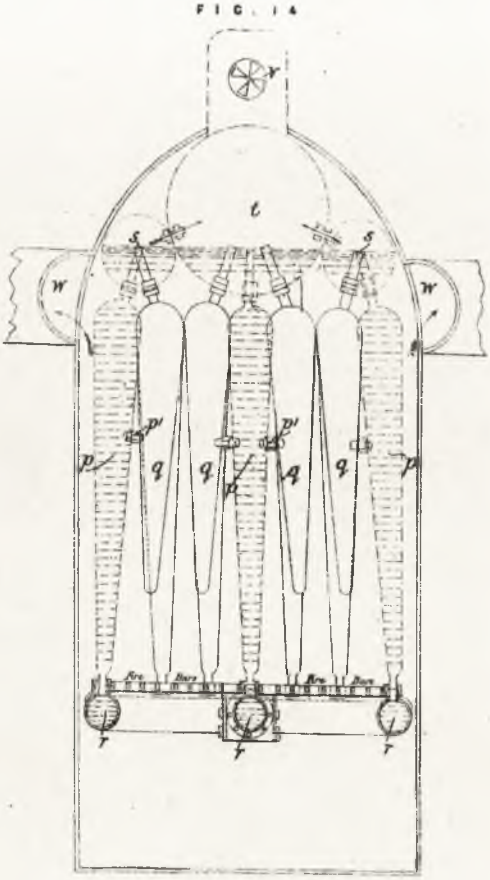


FIG. 14



A.D. 1870, 21st Mar. N° 1469.

Aerial Locomotion.

LETTERS PATENT to Richard Harte, of 42, Argyll Road, Kensington, in the County of Middlesex, Gentleman, for the Invention of "IMPROVEMENTS IN MEANS AND APPARATUS FOR EFFECTING AERIAL LOCOMOTION."

Sealed the 5th July 1870, and dated the 21st May 1870.

COMPLETE SPECIFICATION filed by the said Richard Harte at the Office of the Commissioners of Patents, with his Petition and Declaration, on the 21st May 1870, pursuant to the 9th Section of the Patent Law Amendment Act, 1852.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, RICHARD HARTE, of 42, Argyll Road, Kensington, in the County of Middlesex, Gentleman, send greeting.

WHEREAS I am in possession of an Invention for "IMPROVEMENTS IN MEANS AND APPARATUS FOR EFFECTING AERIAL LOCOMOTION," and have petitioned Her Majesty to grant unto me, my executors, administrators, and assigns, Her Royal Letters Patent for the same, and have made solemn Declaration that I am the true and first Inventor thereof.

[*Price* 8*d*.]

NOW KNOW YE, that I, the said Richard Harte, do hereby declare that the following Complete Specification, under my hand and seal, fully describes and ascertains the nature of the said Invention, and in what manner the same is to be performed, in and by the following statement thereof, that is to say:—

My Invention relates to the support and propulsion of bodies in and through the air, and to apparatus for applying motive power for this purpose. For this purpose I employ a machine moved either by muscular or steam power, consisting of wings which do not move relatively to the other parts of the machine when it is in motion, a screw propeller of the construction herein-after explained, and a weight or beak which has a motion or motions that serve to adjust it so as to maintain the balance of the machine when in motion. The weight or beak is placed in front of and the screw behind the fixed wings when these are in the position they assume in flight. These three component parts of my machine are solidly fastened to a frame which supports them, and on and from which they act, and which frame or body of the machine contains or gives support to the motive power. The wings of my machine form a plane which passes through the air in the direction of its lesser diameter. The beak or balancing weight by its momentum ensures the passage through the air of the front part of my machine, first, the body or frame of the machine by its momentum ensures the passage through the air of my machine, with the under surface of the wings opposed to the action of the air it encounters in its flight. The screw which moves the machine has its axis at a slight angle with the plane of the wings of the machine, and is composed of two fans, which have more of their superficies on one side of their axes than on the other. These fans are free to take a rotatory motion on their own axes, but are held in the position requisite for the rate of flight desired by springs strong enough to prevent them from rotating on their axes when the pressure on their surface is only that caused by the application to the screw of the rotary force necessary to produce the uniform and ordinary velocity of the machine through the air, but which springs are not strong enough to resist a stronger application of force to the axes of the screw, and consequently allow the fans to turn on their axes when such additional force is applied, so as to become the sections of a screw having a closer thread. When no permanent or uniform rate of flight is contemplated the springs are so arranged that the fans will remain completely parallel to the axis of the screw when the rotary motion is not imported to the screw. At the end and back or hinder part of each wing is a flap which moves up and down upon a hinge in the back edge of the wing. This hinge is prolonged in the shape of a rod, and this rod is in connection with a lever, by means of which the flap is made to rise above or fall below the rest of the surface of the wing, this lever being in connection with a second lever which is within reach of the person who steers the machine. The frame rests upon wheels, which wheels consequently support the whole machine when at rest. If muscular power be applied to move the machine the man stands upon treadles communicating with cranks on the axle of the screw. When steam power is applied the necessary apparatus takes the place of the man. In front of the machine is a shade calculated to shelter the passengers from the force of the air encountered in the flight of the machine. With regard to the shape of the frame and of the balconies and platform necessary to protect the passengers from the danger of falling out or down no particulars need be specified, they will depend upon the varying requirements of each class of machine. The wings may or may not be made to revolve upon hinges, so as to have a folding motion.

The action of the machine is as follows:—Motion is communicated to the machine either by a foreign motive power or by running the machine down an inclined plane, or by working the fans with sufficient force to cause them to rotate upon their axes so as to convert the force applied to rotate the screw chiefly into a backward pressure on the air. The beak or balancing weight being as near the centre of gravity of the machine at rest as possible, and the front of the wings being slightly raised so as to allow the air encountered in the forward motion of the machine to act upon the under surface of the plane formed by the wings. As the machine runs along the ground with increasing speed and momentum the pressure of the air upon the under surface of the wing increases, and the weight of the machine relatively to the ground diminishes until it finally rises clear of the ground. The effect of this motion is to cause the fans to approach more and more their normal or fixed position, while the momentum of the body of the machine and the pressure from the screw at the back part of the machine causes the machine to tend to turn, so that the plane of the wings make a less acute angle with the earth's surface. The balancing weight is therefore moved forward by degrees so as to act with greater leverage on the front of the machine until the angle required to establish equilibrium be obtained. The weight of the balancing beak and the size of the wings and the extent of the surface of the fans will in the case of each machine of course depend upon the weight to be carried and the quantity of the motive power. In order to alight the machine is made to describe circles in the air, which have the effect of stopping or checking its velocity. When near the ground the machine is made to travel for a short way with the under surface of the wings exposed very much to the pressure of the air through which the machine moves, until finally all forward motion is overcome when close to the ground, and the machine alights on its wheels. This presenting of the under surface of the wings to the opposing air may be accomplished by lowering or drawing in the beak or balancing weight, or by changing the direction in which the screw exerts its pressure, for which purpose the front end of the axis of the screw may be made to move up and down the front of the frame by means of an endless screw or some other suitable simple mechanical contrivance. With regard to the beak or balancing weight the wheels on which a small machine runs may, when not in use, be employed for the purpose of the beak or balancing weight by being constructed upon a separate framework, and made to turn upon the pivot upon which the balancing weight turns when such weight is a ball or rod of heavy material. In a large machine moved by steam power the machinery may be so arranged as to supply the place of a balancing weight.

It will thus be seen that the principle of my Invention is the analysis of the action of a bird in flying into its component parts, the most important of which are support and propulsion. The former I secure by the wings of my machine, which are so arranged as to rest upon and when propelled with sufficient velocity to move upwards upon the inclined plane of air which is in contact with their under surfaces. The latter I secure by means of my screw propeller with its self-adjusting movement herein-before described, which as it turns exerts an upward and backward pressure upon the air, and therefore a downward and forward pressure upon the machine. This pressure forces the machine forward with a velocity continually increasing until its momentum forces the wings and with them the whole machine to quit the ground and pass up the inclined plane of air above mentioned. The whole machine being thus regarded as an inclined plane the motive power which is applied at the rear, which is also the lowest part of the inclined plane, will have a tendency to turn the forward part up until it will fall over backwards. This tendency I counteract by means of the beak or balancing weight. The motion of the fans of the screw propeller being rotatory tends to give a rotation to the whole machine in the opposite direction. This I counteract by means of the flaps of the wings, each of which acts upon the principle of a ship's rudder, and their combined action is such that when one flap is turned up and the other down they simply counteract this tendency of the machine to rotate and keep it steady. When both flaps are depressed the machine will descend, when both are equally raised it will ascend, and when both are raised but unequally the machine will make a curve towards the side on which the flap is most raised.

What I claim is,—

First. The self-adjusting movement of the fans of my screw propeller as herein-before described.

Second. The arrangement above described of a beak or balancing weight in its relation to the screw propeller.

Third. The arrangement above described of the wings and their flaps for the support and guidance of the machine.

Fourth. The combination herein-before described of the above-named parts of my machine so as to effect aerial navigation.

Description of the Drawings.

Figure I., frame or body of the machine with the beak or balancing weight seen from the side; Figure II., frame or body of the machine with the beak or balancing weight seen from above; Figure III., frame or body of the machine with the beak or balancing weight seen from the front; Figure IV., frame or body of the machine with the fans in position seen from the side; Figure V., plan of one wing and flap; Figure VI., enlarged view of the insertion of the fans into the axle of the screw seen from the side; Figure VII., enlarged view of the insertion of the fans into the axle of the screw seen from above; Figure VIII., rack and pinion for folding wings seen from the front.

a, *a*, *a*, axle of the screw propeller; *b*, beak or balancing weight; *r*, rod that supports the beak; *p*, pivot on which *r*, the rod, turns; *f*, *f*, *f*, *f*, frame or body of the machine; *s*, *s*, the shade or screen;

w, *w*, wheels on which the machine rests; *j*, the junction of the wings; *t*, *t*, the treadles to turn the screw; *k*, *k*, the cranks on which the treadles act; *h*, the hinge of the flap of the wing; *l*, the lever to turn *h*, the hinge; *x*, rack and pinion to fold wings; *n*, *n*, the fans of the screw; *g*, *g*, *g*, the wings; *y*, the flap of the wing; *o*, *o*, socket in which the fans turn; *z*, *z*, stalks or axles of the fans; *d*, *d*, bars for the attachment of the springs to hold the fans in their position; *c*, *c*, catch to prevent *z*, the peduncle of fan from turning too much in *o*, the socket; *e*, box, in which the front of the screw plays; *q*, screw to move *e*, the box, up and down in the frame.

In witness whereof, I, the said Richard Harte, have hereunto set my hand and seal, this Twentieth day of May, in the year of our Lord One thousand eight hundred and seventy.

RICHARD HARTE. (L.S.)

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.-
[Wt. 25—26/5/1909.]

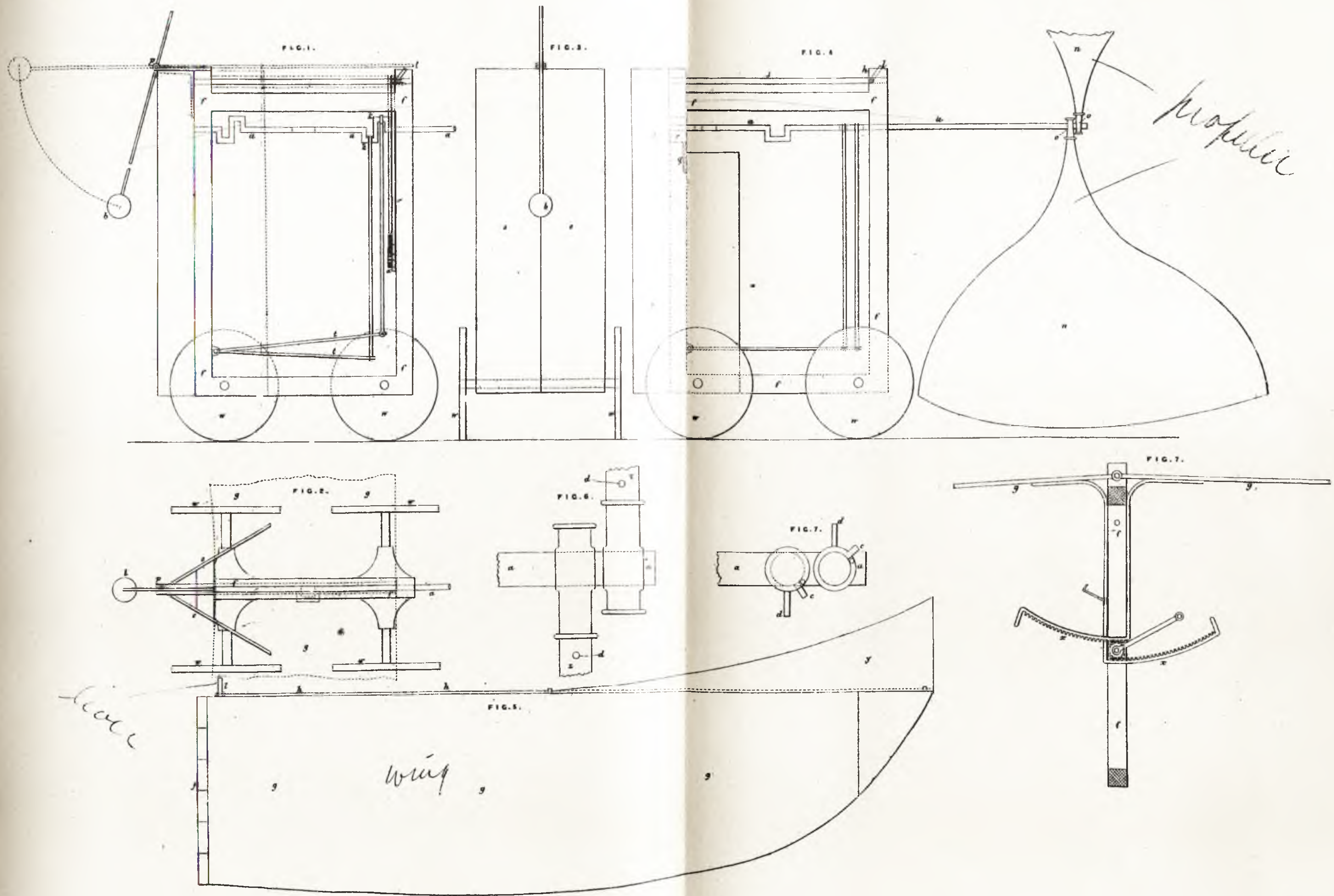
— Does not mention lat. equilibrium
— Does not appear to have known aeroplane must have lat. bal.
— Proposed opposing torque or turning tendency of propellers by flaps (turning one up & one down) — (But never tried)
— Proposed (but never tried) steering by flaps — like Mouillard

A.D. 1870. May 21. N°. 1469.

HARTE'S Complete Specification

(2nd Edition)

(1 SHEET)



The filed drawing is not colored

Malby & Sons. Photo-Litho.

[Third Edition.]

N° 16,883 A.D. 1889

Date of Application, 25th Oct., 1889
Complete Specification Left, 23rd Aug., 1890—Accepted, 18th Oct, 1890

PROVISIONAL SPECIFICATION.

Improvements in and relating to Aeronautic Apparatus.

I, Hiram Stevens Maxim of Crayford Works, Crayford, in the County of Kent, and Victoria Mansions, Victoria Street, in the City of Westminster, Mechanical Engineer, do hereby declare the nature of this invention to be as follows:—

My invention relates to apparatus for aerial navigation and comprises various improvements which are partly applicable for other purposes.

Numerous attempts have heretofore been made in various countries to produce a machine for navigating the air. All these attempts have failed, generally by reason of the great weight of the generator and motor in proportion to their power. In some of the aerial-machines heretofore devised, there is an inclined plane or kite designed to be driven forward, by means of screw-propellers, with such velocity that the machine will, while moving forward, be raised from the ground by the air acting upon the said inclined plane. But in all the machines of this kind heretofore constructed, with the exception of those in which the motor consists of compressed air or of a twisted string of india-rubber, which can only operate for a comparatively very short time, the power of the generator and motor in proportion to their weight has been such that the apparatus has travelled, or had a tendency to travel in a direction the reverse of that intended by the inventor.

Now my invention is chiefly designed to overcome the difficulties heretofore experienced and to provide for the construction of an aeronautic machine which can, while moving forward in the air, be caused to rise or descend at any desired velocity or to travel at any predetermined height above the ground.

I accomplish this result as follows, *viz.*: I provide an adjustable covered framework or kite of very large dimensions which is pivoted to the main-frame or car of the machine so that it can be set and secured at any desired angle or inclination, thus affording an inclined plane against which the air will act to raise the machine while moving forward. For convenience of description I will hereinafter term this covered framework or kite an "aeroplane." I combine with this aeroplane, a generator and motor the weight of which is very small in proportion to their power, and suitable propellers to be driven by the said motor.

I find it advantageous to use for this purpose a generator and an engine or motor such as are described in the Provisional Specification lodged with my application for Letters Patent dated 25 June, A.D. 1889, No. 10,359, that is to say: A generator which consists essentially of tubes of comparatively large diameter connected by tubes of very small diameter so that the water is divided and subdivided into very fine or thread-like streams and will be very rapidly converted into steam by the heat applied to the exterior of the said tubes; and a motor having all the parts where practicable made hollow or tubular and very light. The generator is heated by means of liquid hydrocarbon which is vaporized and fed as required to suitable burners arranged beneath and enclosed by the tubes of the said generator. In each revolution of the engine a quantity of water is forced into the generator equal to that used in the engine in the form of steam. Moreover provision is made for regulating the supply of fuel to the burners in proportion to the water forced into the boiler.

By reason of the above mentioned construction of the generator the weight of water contained therein will be very small and only a small quantity of water need be carried in the supply tank or reservoir, the water being circulated very rapidly through the generator motor and condenser. Moreover, the weight of liquid-fuel that has to be carried in the apparatus is very small compared with that of coal. The weight of the load to be carried by my aerial-machine is therefore greatly reduced as compared with other machines for a like purpose heretofore devised.

In the said engine or motor (which is preferably a compound engine) the frame, the crank-shaft, the connecting and excentric rods and other parts are made hollow or tubular and as light as is practicable consistent with the requisite strength; provision is made for the circulation of cooling liquid through the crank-shaft, or the said shaft is filled with liquid to obviate overheating of the bearings; and the connecting and excentric rods are so constructed that they may be filled with oil or other lubricant and serve as lubricators. In this manner I am enabled to construct an engine or motor of great power and of comparatively light weight. The motor is, moreover, provided with a thermo-static regulator such as is described in my said former Provisional Specification, that is to say, a regulator comprising a valve which is held away from its seat by a spring, against which bears a diaphragm acted upon by fluid pressure from a pipe containing liquid and arranged in a part of the generator in the immediate vicinity of the burners.

The main frame of my apparatus is composed of hollow rods or tubes rigidly united in any convenient manner. It is provided with wheels whereby it may be caused to run upon or between rails before rising from the ground. The bottom of the said frame is preferably filled in with wire-netting, and the boiler or generator is supported upon this netting, which forms an elastic support therefor. From this frame extend upward hollow rods or tubes, to the upper ends of which is pivoted the kite or aëroplane. This aëroplane may consist of a frame formed of hollow rods or tubes rigidly united in any convenient manner, the said frame being covered with silk or other suitable material. The said kite or aëroplane is connected with one or more winches by ropes or chains passed over suitable pulleys in such a manner that, by turning the winch or winches in one or the other direction, I can simultaneously draw in the ropes at one end of the said aëroplane and slacken those at the other end thereof, and thus set or adjust the said aëroplane to any desired angle or inclination. Or I provide other suitable means for adjusting the said aëroplane. To each side of the kite or aëroplane are pivoted suitable wings. These wings and the aëroplane are provided with stays or ropes for strengthening them and maintaining them in the desired position.

The engines or motors (of which I prefer to employ two) are carried by supports extending upward from the main frame, and a screw-propeller is fixed on the shaft of each engine or motor. The said propellers are provided with any suitable number of blades each consisting of a frame or spokes of metal, wood or other suitable material covered with silk or the like. The machine is so constructed that the exhaust-steam from the engines will pass through one of the supports and through the lower part of the main frame, and will then ascend into and pass through the frame of the aëroplane and then through a suitable condenser (or through the aëroplane itself when this is used as a condenser as hereinafter mentioned) and back to the feed-pump. The aëroplane must be pivotted to main frame in such a manner as to permit the passage of fluid into the aëroplane whilst preventing escape of the fluid at the joint.

I find it advantageous to make each screw propeller of a steel or other metal tube or hollow shaft having fixed therein other tubes which extend transversely through the said hollow shaft alternately in directions at right angles to each other. These transverse tubes are so arranged as to correspond to the desired pitch of the screw. Rods of wood or other suitable material of much greater length than the tubes are passed through and secured in the said transverse tubes, and the whole is covered with silk or other material, which is stretched in the proper direction to assist in resisting the centrifugal force which, in the rotation of the propeller, tends to destroy or injure the blades; the said tubes and rods form the spokes or frame of the propeller-blades. The blades thus constructed are very strong and are not liable to injury by the centrifugal force generated by the rotation of the propeller.

The condenser is, in some instances, formed partly of some of the hollow rods or tubes which constitute the frame of the aëroplane. These tubes are connected by other tubes so formed that steam will pass through them in thin films of considerable width, and are so arranged that the atmosphere will very effectually cool them, thus condensing the steam, which will descend in the form of water into the lower tube of the condenser and flow thence to the feed-pump. These flat or film tubes are preferably arranged vertically, with a small space between them. They may, however, be otherwise arranged if desired.

In order to condense the steam by the cooling effect of the atmosphere, it is necessary to have a very large condenser. It is therefore desirable that the said condenser should serve some other purpose besides that of merely condensing the steam. In some instances, I utilize the kite or aeroplane as a condenser, making the same of sheet metal secured upon a suitable framing so that it encloses a large space the depth of which is very small. For example, I make the aeroplane like a large flexible bag or chamber, and I connect the forward end thereof with the exhaust-pipe and the rear end thereof with the hotwell or directly with the suction of the feed-pump. The pressure in this condenser should be the same as that of the air outside thereof, so as to keep the bag distended and utilize the buoyancy or lifting power of the steam to counteract the weight of the apparatus. Or I utilize only the forward part of the said aeroplane as a condenser.

The engine-frames are also made hollow and each engine is connected by a belt with a pulley for working the feed and fuel pumps, preferably in such a manner that whichever engine is moving with the higher velocity will drive the said pumps.

The outer end of one pair of cylinders is secured to the outer end of the other pair of cylinders by one or more hollow rods or tubes forming braces which strengthen the frame-work, and bearings which support the pulley for driving the pumps.

Moreover I provide means whereby, when the apparatus descends, it may be caused to alight upon the ground without excessive shock or concussion; for instance I mount the wheels upon an axle or axles carried by levers or arms pivoted to the main frame. Suitable rack-bars are pivoted to the said axle or axles and are geared with pinions on a shaft provided with a drum or pulley for winding up a rope or cord attached to the wings of the apparatus, for the purpose hereinafter specified. Suitable rollers carried by brackets are provided for retaining the racks in gear with the pinions. The axles of the wheels are preferably made of bamboo to ensure elasticity of the said axles. When the wheels come in contact with the ground, the main frame continues to descend so that the rack-bars act upon the pinions and wind up the rope or cord, thus suddenly and rapidly depressing the wings and checking or counteracting the downward movement of the apparatus. It is obvious that I can, if desired, vary the means used for obviating excessive shock or concussion of the apparatus on reaching the ground.

I find it advantageous for the purpose of starting the apparatus to employ rails suitably arranged one above another so that the wheels of the apparatus can roll freely between the said rails. I am thus enabled to ascertain, before the apparatus rises into the air, the exact inclination of the aeroplane requisite to ensure the rising of the apparatus when driven at any given velocity. For this purpose I adjust the said aeroplane from time to time and observe whether the wheels run in contact with the lower rail or with the upper rail. I can, therefore, adjust the aeroplane to the required inclination before allowing the apparatus to rise in the air.

I provide for steering or manœuvring the machine as hereinafter described. It is obvious that a machine for navigating the air has to be steered vertically as well as horizontally that is to say, it has to be steered in such a manner that it will move horizontally or ascend or descend as required, and also in such a manner that it will move forward in the desired direction.

It is desirable, in some cases, that the steam pressure in the generator should be maintained constant notwithstanding variations in the speed of the engine. For this purpose, I provide a steam-regulator which will act upon the combined feed and fuel pumps in such a manner that, when the steam rises above or falls below the required pressure, it will shorten or lengthen the stroke of the said pumps, thus increasing or diminishing the quantity of water introduced into the boiler and the quantity of fuel fed to the burners for the purpose of evaporating the water. In this manner I provide for ensuring that the pressure in the boiler shall remain constant whatever may be the quantity of steam used in the engine.

To provide for causing the machine to travel horizontally, that is to say, to move forward at any predetermined distance above the ground, I employ a barometric regulator. For example I attach a barometer to gearing for changing the length of stroke of the feed and fuel pumps, so that, if the aeroplane is set at the required angle to maintain the machine in equilibrium, that is to say, neither falling nor rising, then, should the machine, by reason of any change of conditions, approach the earth, the pressure on the barometric regulator becoming increased, the length of stroke of the pumps will be correspondingly increased, thus raising the pressure in the boiler by augmenting the generation of steam therein. When the pressure is increasedsufficiently to drive the machine forward at a higher velocity, the machine will rise slowly until it reaches the height for which the regulator is adjusted. If, on the other hand, the machine should rise above this height, the regulator will act in the contrary direction, and cause a reduction of pressure in the boiler, which will again bring the machine back to the predetermined distance above the ground.

I sometimes construct my barometric regulator as follows, *viz.*:—I employ a lever for operating the combined feed and fuel pumps. The short arm of this lever is connected to the pump rods, and on the long arm of the said lever is mounted a sliding block or sleeve. This block or sleeve is connected by means of a rod or link to a crank operated by the engine. I provide for automatically adjusting the said sliding block towards or away from the fulcrum of the lever according to the variations of barometric pressure. For example, I arrange in the said lever a screw which engages with the said sliding block or sleeve, and I connect this screw by suitable gearing with a toothed wheel, to which motion is imparted alternately in either direction by the movement of the said lever. In combination with this toothed wheel, I provide a double or two-armed pawl mounted on a shaft or stud and having secured to it a lever, one end of which is acted upon by a spring and the other end of which is connected with an aneroid barometer. Any increase of barometric pressure will turn the said lever and pawl in one direction about their pivot and thus cause one arm of the pawl to engage with the toothed wheel, so that, in the operation of the pump-lever, the said pawl will prevent the turning of the wheel in one direction and thus cause the operation of the screw in such a manner as to move the sliding block or sleeve along the pump-lever towards the fulcrum thereof, thus increasing the stroke of the pumps and consequently augmenting the quantity of steam generated in the boiler. When the barometric pressure diminishes, the spring will cause the other arm of the pawl to engage with the opposite side of the toothed wheel, so that, in the movement of the pump-lever, the screw will turn in the reverse direction, thus diminishing the stroke of the pumps. I prefer to arrange suitable springs at each end of the said screw and to make the said screw of such length that, should the turning of the screw in either direction be continued so as to bring the sliding block to either end of its stroke or movement, the said block will compress the corresponding spring and move out of engagement with the said screw; and the said spring will ensure the re-engagement of the block with the said screw, when the direction of rotation of the latter is reversed.

In another form or modification of my barometric regulator, the lever connected with the pumps is curved and the sliding block thereon is attached to an arm coupled to a disc-crank on the driving shaft. The said arm is also coupled to a toothed wheel fixed upon another shaft. A vibrating lever is provided at one end with a slot in which works a pin or stud fixed in the aforesaid disc-crank. Two rack-bars are coupled to this lever, on opposite sides of the fulcrum of the said lever, and are adapted to engage with opposite sides of the said toothed wheel. These rack-bars are coupled to a rod arranged to be moved by the barometer so as to bring one of the said rack-bars intoengagementwith,andsimultaneouslydisengage the other rack-bar from the said toothed wheel. Suitable means are provided for adjusting the regulator for any predetermined height.

The load of fuel and water will necessarily diminish while the machine is in use, and if it is determined to fly always at the same height, the pressure in the boiler must diminish as the load becomes less. My improved barometric regulator accomplishes this result very effectually.

It is not desirable that the exhaust-steam from the engine shou'. be used for blowing the fire, because the water would, under such circumstances, very soon be all evaporated. It is therefore necessary to provide other means for promoting the combustion of the fuel, and to condense the steam. I so construct the generator that the forward motion of the machine will cause air to enter below the burners and be forced upward between the tubes of the generator, the heated air and products of combustion escaping at the top of the generator.

The condenser hereinbefore described is very advantageous for my improved aërial machine and can also be used for other machines designed to travel through the air.

I sometimes provide a rudder or rudders in rear of the propellers.

In place of the generator and motor hereinbefore described, I can, if desired, employ any other generator and engine or motor suitable for my purpose.

Dated this 25th day of October 1889.

HASELTINE, LAKE & Co.,
45, Southampton Buildings, London, Agents for the Applicant.

COMPLETE SPECIFICATION.

Improvements in and relating to Aeronautic Apparatus.

I, Hiram Stevens Maxim, of Crayford Works, Crayford, in the County of Kent, and Victoria Mansions, Victoria Street, in the City of Westminster, Mechanical Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

My invention relates to apparatus for aerial navigation.

Numerous attempts have heretofore been made in various countries to produce a machine for navigating the air. All these attempts have failed, generally by reason of the great weight of the machine and its load in proportion to the power of the generator and motor. In some of the aërial machines heretofore devised, there is an inclined plane or kite which is intended to be driven forward by means of screw-propellers, with such velocity that the machine will while moving forward, be raised from the ground by the action of the air upon the said inclined plane. But, in all the machines of this kind heretofore constructed (with the exception of those in which the motor consists of compressed air or of a twisted string or cord of india-rubber), the weight of the entire machine and its load in proportion to the power of the generator and motor has been such that the apparatus has travelled, or had a tendency to travel in a direction the reverse of that intended by the inventor, that is to say, downward instead of upward.

In machines of this kind driven by compressed air or by a twisted string or cord of india-rubber all the energy to be used for driving the machine must be stored in the same before starting it, and as soon as this energy is expended, the machine will descend. It is evident, therefore, that such machines can only operate for a comparatively very short time.

Now my invention is chiefly designed to overcome the difficulties heretofore experienced and to provide an aerial machine in which power for driving the same can be generated while it is moving through the air, and which can be driven forward with sufficient velocity to overcome the action of gravity when the inclined plane or kite (or what I term the "aeroplane") is at a suitable angle or inclination to the horizontal plane, so that the machine can be caused to rise in the air without the aid of a balloon, or can be caused to descend in the air with greater or less velocity as desired, or to travel forward at any predetermined distance above the ground.

For this purpose I construct the generator and motor and other parts of the machine in such a manner as to obtain great lightness thereof combined with the requisite strength, and I make the generator and motor very powerful in proportion to the weight of the entire machine and its load and to the dimensions of the inclined plane or kite. Moreover I provide suitable means whereby the speed of the engine or motor and the angle or inclination of the kite relatively to the horizontal plane can be easily varied for the purpose of regulating the movement of the machine through the air. And I so construct the kite as to ensure stability or steadiness of the machine while moving through the air, and thus obviate any liability to pitching which might otherwise be caused by the unequal action of the air upon the forward and rear portions of the kite. I also provide suitable means for ensuring the safe descent of the machine in case of accident or injury to the generator and motor.

I find it advantageous to use, for the purpose of my invention, a steam generator and motor such as I have described in the Specification of former Letters Patent granted to me and dated 25th June A.D. 1889, No. 10359.

To provide for regulating the height at which the machine shall travel through the air, and for causing it, when desired, to travel horizontally, that is to say, to move forward at any predetermined distance above the ground, I employ a barometric regulator which effects the desired result by varying the speed of the engine or motor according to any increase or diminution in the pressure of the air acting upon the barometer. For instance, I combine a suitable barometer with mechanism for changing the length of stroke of the fuel-pump or of the feed-water and fuel-pumps, so that, if the kite or aeroplane is set at the required angle to maintain the machine in equilibrium, that is to say, neither falling nor rising, then, should the machine, by reason of any change in the conditions under which it is working (such as diminution of its weight by reason of the consumption of fuel and water) approach the earth, the pressure on the said barometer being increased, the length of stroke of the said pump or pumps and consequently the amount of water and fuel supplied to the generator or boiler will be correspondingly increased, thus raising the pressure in the boiler by augmenting the generation of steam therein. When the pressure is increased sufficiently to drive the machine forward at a higher velocity, the machine will rise slowly until it reaches the height for which the barometric regulator is adjusted. If, on the other hand, the machine should rise above this height, the regulator will act in the contrary direction and cause a reduction of pressure in the boiler, thus diminishing the speed of the engine or motor and bringing the machine down to the predetermined distance above the ground.

In manœuvring the machine (for example causing the same to turn rapidly to the right or left or to ascend or descend), varying quantities of steam will be used in the engine or motor. In order that certain manipulations of the controlling valves shall always produce the same effect in respect of variation of the speed of one or both of the engines, it is advantageous that the steam-pressure in the generator shall be maintained constant, notwithstanding variations in the speed of the engine and consequently in the amount of steam used therein. For this purpose, I provide a steam-regulator which acts upon the fuel-pump or upon the combined feed and fuel pump in such a manner that, when the steam rises above or falls below the required pressure, it will shorten or lengthen the stroke of the said pump, thus increasing or diminishing the quantity of water introduced into the boiler and the quantity of fuel fed to the burners for the purpose of evaporating the water. In this manner I provide for ensuring that the pressure in the boiler shall remain constant whatever may be the quantity of steam used in the engine.

My said invention, moreover, comprises other improvements hereinafter set forth.

In the accompanying drawings, I have shown how my said invention may be conveniently and advantageously carried into practice.

Figure 1 is a front elevation of one form of my improved aerial machine, some of the parts being removed.

Figure 2 is a vertical longitudinal section on the line x, x, Figure 1.

Figure 3 is a front elevation of one half of the said machine, showing one of the lateral extensions or wings hereinafter described.

Figure 4 is a plan of a portion of the machine, drawn to an enlarged scale.

Figure 5 is an underside view, partly in longitudinal central section, drawn to a further enlarged scale, showing an improved condenser hereinafter described.

Figure 6 is a section on the line y, y, Figure 5, drawn to a still further enlarged scale.

Figures 7, 8 and 9 are different views, also drawn to an enlarged scale, showing details of construction hereinafter described.

Figure 10 is a side elevation, and

Figure 11 a front elevation of one of the screw-propellers, drawn to an enlarged scale, some of the parts being removed.

Figure 12 is a vertical longitudinal central section, drawn to an enlarged scale, showing an improved device hereinafter described for imparting motion to the mechanism for working the feed-water and fuel pumps.

Figure 13 is a front elevation partly in vertical section, and

Figure 14 a central transverse section, showing a part of the device illustrated in Figure 12.

Figure 15 is a side elevation of another part of the said device.

Figure 16 is a side elevation, partly in vertical section, and

Figure 17 a front elevation, also partly in vertical section, showing a device hereinafter described for diminishing the shock or concussion when the apparatus alights upon the ground.

Figure 18 is a plan, partly in horizontal section, and

Figure 19 a side elevation, partly in vertical section, showing one form of my improved barometric regulator hereinafter described.

Figure 20 is a transverse section on the line z, z, Figures 18 and 19.

Figure 21 is a side elevation, partly in vertical section, showing one form of my improved steam-regulator hereinafter described.

Figure 22 is a plan, some of the parts being removed, and

Figure 23 a side elevation, some of the parts being removed, illustrating another form or modification of my aerial machine, and

Figure 24 is a side elevation showing a rudder applied to the aërial machine, for effecting, or assisting to effect the horizontal steering of the same.

Like letters indicate corresponding parts throughout the drawings.

A is the main frame or car, which is composed of hollow rods or tubes of steel or other suitable metal rigidly united in any convenient manner. B is an adjustable frame-work, kite or "aeroplane." C is the steam generator or boiler. D, D are the engines or motors. E, E are the screw propellers. F, F are wheels which are mounted upon axles F^1 attached to the frame or car A in the manner hereinafter described, and which are adapted to run between upper and lower rails whereby the machine, while moving forward, will be held down, to permit the trial of the machine and the proper adjustment of the same as hereinafter specified, before it is allowed to rise from the ground. The bottom of the main frame or car A is preferably filled in with wire-netting, and the boiler or generator C may be supported upon this netting which forms an elastic support therefor. A^* is a hand-rail which is also formed of hollow rods or tubes, and which serves to still further strengthen the said main frame or car A. C^1 is an uptake or chimney for the escape of the waste products of combustion from the boiler or generator C.

The kite or "aëroplane" B consists of a frame which is formed of hollow rods or tubes of steel or other suitable metal rigidly united in any convenient manner, and which is covered with silk or other suitable material. The said kite or "aëroplane" is pivoted at B^1 (as more clearly shown in Figures 1, 3, 5, 7 and 8) to the ends of a cross-piece or stay B^2 firmly secured to the upper ends of hollow rods or tubes A^1, the lower ends of which are secured to the main frame or car A. The cross-piece B^2 is connected to the kite or aeroplane B (as more clearly shown at Figures 7 and 8) in such a manner as to permit the passage of the exhaust-steam from the engine through the said cross-piece into the kite or aëroplane (part of which serves as the condenser as hereinafter described), whilst preventing escape of the fluid at the joints. Figure 9 shows an advantageous method of securing the extensions or supports A^1 to the main frame or car A. Other joints in the said main frame or car A and in the kite or aëroplane B may be advantageously formed in a similar manner.

The said kite or aëroplane is connected at its ends with one or more winches by ropes or chains passed over suitable pulleys, in such a manner that, by turning the winch or winches in one or the other direction, the ropes at one end of the aërial machine can be simultaneously drawn in and those at the other end thereof slackened or paid out, or *vice versa*, and the kite or aëroplane thus set or adjusted to the desired angle or inclination relatively to the horizontal plane. The above mentioned winches and ropes or chains are omitted from the drawings for the sake of clearness; the said winches may be of any well-known or other suitable construction. Adjustable counterweights or other convenient devices may, if desired, be employed either in lieu of, or in combination with the said winches for the purpose of varying the angle of the said kite or aëroplane relatively to the horizontal plane. Or the kite or aëroplane may be rigidly connected to the main frame or car and a suitable counterweight be provided for varying the position of the centre of gravity of the machine and thus adjusting the angle of the kite to the horizontal plane. Suitable guy-ropes or stays B^3 and struts or supports B^4 are, moreover, provided for strengthening and stiffening the said kite or aëroplane and maintaining it in its proper form.

The kite or aëroplane is provided on each side with lateral extensions or wings, as at G Figure 3, each of which is formed of a framework of hollow rods or tubes covered with silk or other suitable material, and which are hinged or pivoted at G^1, G^1, to the sides of the kite or aëroplane B.

For convenience of illustration, the silk or other covering is removed from the kite or aëroplane B and from the wings G shown in the drawings. If desired, the said wings may be pivoted to the main frame or car A instead of to the kite or aëroplane B.

The engines or motors D are supported partly by hollow rods or tubes A^2 and partly by the steam and exhaust pipes A^3, A^4, which rods or tubes and pipes form part of the frame of the machine. The rods or supports A^2 and the exhaust-pipe A^4 extend upward from the main frame or car A, and the steam-pipe A^3 extends from the stop-valve on the boiler to the engine or motor. A^5, A^5 are hollow rods or supports also extending upward from the main frame or car A, and having at their upper ends suitable bearings A^6 for supporting the crank-shafts D^1, the said shafts being also supported in the frames of the engines or motors D. A^7 is a cross-piece or stay for further stiffening and strengthening the rods or supports A^5.

C^2 is a thermostatic regulator such as that described in my said former Specification, for governing the supply of hydrocarbon or other liquid fuel to the delivery-nozzle or injector C^3. C^4 is a tank or reservoir situated in the forward part of the apparatus, for containing a supply of hydrocarbon or other liquid fuel. The tank C^4 is connected with the fuel-pump C^5 by means of a pipe C^6, and the said pump is connected with the delivery-nozzle or injector C^3 by means of a pipe C^7. This pipe C^7 is preferably passed through the upper part of the generator C, and is arranged therein in the form of a coil for vaporizing the liquid hydrocarbon on its way to the nozzle or injector C^3. C^8 is the pipe by means of which the pressure from the generator C is communicated to the diaphragm and valve of the thermostatic regulator, as described in my said former specification.

A screw-propeller E is fixed upon each of the crank-shafts D^1. The said propellers are provided with any suitable number of blades, each consisting of a frame or series of spokes E^1 (Figures 10 and 11) of metal, wood or other suitable material, covered with silk or the like. The said covering extends to within a suitable distance of the central portion or boss of the propeller.

I prefer to construct the propellers as shown more clearly in Figures 10 and 11, that is to say: The spokes E^1 are secured in steel or other tubes or sockets E^2 which are firmly secured, by means of a screw-bolt E^3 (or in any other convenient manner) in a hollow boss or tube D^2 having a flange D^3 whereby it is firmly attached, by bolts or otherwise, to the hollow crank-shaft D^1; or the said tubes or sockets E^2 may, if desired, be secured in the end of the hollow crank-shaft D^1 in any convenient manner.

I sometimes make the sockets E^2 taper from the centre, or near the centre to both ends thereof, and I provide upon the said ends suitable beadings or flanges of smaller diameter than the said central portions. Upon the said central or enlarged portions I provide screw-threads adapted to fit into correspondingly screw-threaded holes in the hollow boss or tube D^2, and I cut away a portion of the said enlarged or central portions so as to allow of the tubes or sockets being passed through the said holes in the hollow boss or tube and screwed therein.

The tubes or sockets E^2 extend transversely through the said hollow boss or tube D^2 alternately in directions approximately at right angles to each other. These transverse tubes or sockets are so arranged as to correspond to the desired pitch of the screw. The spokes E^1 are of much greater length than the tubes or sockets E^2 and are passed through, and firmly secured in any convenient manner in the said sockets, the whole being covered, as above mentioned, to within a suitable distance of the hollow boss or tube D^2, with silk or other suitable material; this material should be stretched in such a direction that it will assist in resisting the centrifugal force set up by the rotation of the propeller, which tends to destroy or injure the blades thereof. The blades thus constructed are very strong and are not liable to injury by the centrifugal force generated by the rotation of the propeller.

Each of the said propellers E is provided, moreover, with a strut E^4 (Figure 2) and with stays, ropes, cords or wires E^5 for further stiffening and strengthening the said propeller and assisting to resist the strains to which it is subjected when working.

H is the engine-condenser, which forms a part of the kite or aeroplane B and which is constructed in the manner hereinafter described.

The aerial machine is so constructed that the exhaust-steam from the engines will pass through the hollow supports or exhaust-pipes A^4 and through the lower part of the main frame or car A, and will then ascend through the hollow rods, supports or tubes A^1 and pass through the cross-piece B^2 and through the frame of the kite or aeroplane B and the condenser H, or through the entire body of the kite or aeroplane when this is used as a condenser as hereinafter mentioned.

The condenser H comprises a large number of wide flat or film tubes, that is to say, tubes of thin metal having a flat bore through which the steam will pass in thin films of considerable width. These tubes are shown more clearly in Figures 5 and 6; they are combined with hollow rods or tubes B^* constituting part of the frame of the kite or aeroplane B. The said hollow rods or tubes B^* are connected by means of short tubes or nipples H^1 with the said flat or film tubes H. These film tubes are so arranged that, in the forward movement of the machine, the air will impinge upon them, thus very effectually cooling them, and condensing the steam therein. It is evident that the said condenser H will, at the same time, by its action upon the air, raise or sustain, or assist in raising or sustaining the machine in the air during its forward movement. Moreover the said condenser being arranged above the feed-water pump, the water of condensation will flow by gravity to the said pump, that is to say, the water of condensation from the tubes H will descend into the lower tube B^* of the condenser, and flow thence through pipes H^2 to small reservoirs or water-tanks I connected with the suction side of feed-water pump I^1 by means of pipes I^2. I^3 is the delivery or feed pipe to the boiler or generator C. The flat or film tubes H may be arranged vertically with a small space between them; or they may be placed at the same angle as the kite or aeroplane B, as shown in the drawing so as to utilize the action of the air upon them for raising or sustaining the machine, or they may be otherwise arranged if desired.

In the forward movement of the kite or aeroplane, the air acted upon thereby will be drawn forward, and the air thus set in motion will be acted upon by the screw-propellers; the positive slip of the said propellers will thus be considerably diminished,

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It will be seen, therefore, that the condenser H also assists in imparting forward motion to the air to be acted upon by the propellers.

B^5, B^6, Figures 5 and 8, are division-plates for regulating or directing the flow of the steam through the frame of the kite or aeroplane to the condenser, and that of the condensed steam or water therefrom. To permit the condenser to participate in the movements of the kite or aeroplane about its pivots, I make a portion of the pipes or tubes H^2 of suitable flexible material.

The shafts D^1 of the engines are provided with pulleys D^4 connected by belts J, J^1 (shown in dotted lines in Figures 1 and 4) with pulleys K, K^1, for working the feed-water pump I^1 and the fuel-pump C^5. The belt J^1 is crossed so that the said pulleys will be rotated in the same direction, although the engines are running in opposite directions. The pulleys K, K^1 are fitted to rotate upon a shaft or spindle L supported in suitable bearings D^5 carried by rods or tubes D^6. These rods or tubes connect the outer end of one pair of cylinders to the outer end of the other pair of cylinders, and form braces for strengthening the framework, and they are connected with the main-frame or car A by hollow rods or supports D^7. The pulleys K, K^1 are mounted freely upon the shaft or spindle L and are connected therewith by a device such as I have described in the said former Specification, so that, when the engines are running at equal velocities, the pumps will be driven by both engines, but when the said engines are running at unequal velocities, the said pumps will be driven by whichever engine is running at the higher speed.

In Figures 12, 13, 14 and 15, I have shown improved apparatus of this kind, so constructed as to ensure lightness of the parts combined with the requisite strength. N is the double ratchet-wheel, which is firmly secured in any suitable manner upon the shaft or spindle L between the pulleys K, K^1. The teeth N^1 of this ratchet-wheel are geared with corresponding teeth K^2 on the bosses K^3 of the said pulleys K, K^1 as described in my said former Specification. N^2, N^2 are the spiral springs which maintain the teeth K^2 of the bosses K^3 in engagement with the teeth N^1 of the ratchet-wheel N. For the sake of lightness, the shaft L is made hollow or tubular; the bosses K^3 of the pulleys are, moreover, recessed internally as shown more clearly in Figures 12 and 14, and the spokes K^4 of the said pulleys are made hollow or tubular, and are screwed or otherwise firmly secured in the bosses K^3, the said bosses being made with hollow projections or sockets to receive the spokes; and the said spokes are brazed or otherwise firmly secured to the rim of the pulley. L^2 is a crank-arm which is firmly secured upon the shaft L, and the crank-pin L^3 whereof is coupled by means of a suitable connecting-rod L^4 (Figure 2) with an arm or lever O secured upon a rock-shaft O^1 as hereinafter described, for operating the feed-water and fuel pumps I^1 and C^5.

To avoid or diminish the shock or concussion when the apparatus descends or alights upon the ground, I provide the mechanism hereinafter described, that is to say: I support the axles F^1 in suitable bearings P at the free end of levers or arms P^1, which are pivoted at P^2 to the main frame or car A. Rack-bars Q are pivoted at Q^1 upon the said axles F^1 and are geared with pinions R fixed upon hollow shafts or spindles S, on which are also fixed drums or pulleys S^1 (more clearly shown in Figures 16 and 17) for winding up ropes or cords T attached at one end to the drums S^1 and at the other end to the wings G of the apparatus (as shown in Figure 3). Suitable anti-friction rollers U carried by arms or brackets U^1 (Figure 16) are provided for retaining the rack-bars Q in gear with the pinions R. The axles F^1 may be formed of hollow or tubular rods of steel or other suitable metal as shown in Figures 16 and 17. I prefer however, to make them of bamboo as shown in Figures 1, 3 and 4, so that they shall have lightness and elasticity combined with the requisite strength. U^2, U^2 are idle rollers supported in brackets U^3 attached to the main frame A, for guiding or directing the ropes or cords T.

When in the descent of the machine, the wheels F come in contact with the ground, the main frame A continues to descend, so that the rack-bars Q act upon and rotate the pinions R and consequently the shafts or spindles S and drums or pulleys S^1, thus winding the ropes or cords T upon the said drums and suddenly and rapidly depressing the wings G and checking or counteracting the downward movement of the apparatus.

I can, if desired, use other suitable means for avoiding or diminishing the shock or concussion imparted to the apparatus on reaching the ground.

It is evident that a machine for navigating the air must be steered vertically as well as horizontally, that is to say, it must be steered in such a manner that it will move in a horizontal plane, or will ascend or descend as required in a more or less inclined plane, and also in such a manner that, while travelling in such horizontal or inclined plane, it will proceed in the desired direction, that is to say, in the direction of any desired point of the compass. The vertical steering of the machine is effected by varying the speed of the propellers and thus increasing or diminishing the velocity at which the machine moves through the air; the action of the kite or aëroplane upon the air is thus varied so as to cause the machine to ascend or descend as required. Or the vertical steering is effected by varying the angle or inclination of the kite or aëroplane or of a rudder or tail pivoted to the body thereof. For steering or manœuvring the machine horizontally, that is to say, for causing it to travel in the required direction in the said horizontal or inclined plane, I provide for varying the relative speed of the two propellers as required.

To facilitate the steering or manœuvring of the machine, I employ stop cocks or valves A^8 constructed substantially as described in my said former Specification, for regulating or controlling the supply of steam to the engines and thus varying the speed of either or both of the propellers as required.

I sometimes provide a suitable seat or platform for the operator or engine-driver, or I so arrange the main frame or car A that the operator or engine-driver can stand in such a position that he is able to conveniently operate either of the said stop cocks or valves and thereby admit more or less steam to either of the engines or motor D and increase or diminish the speed thereof, and consequently that of the propellers E. I thus provide for very efficiently steering or manœuvring the machine in a horizontal or inclined plane by varying the relative speed of the engines or motors D. If necessary or desirable, I also provide a rudder or rudders between or in rear of the propellers, as shown, for example, at A^9 Figure 24

Figures 18, 19 and 20 illustrate one form of my barometric regulator for automatically regulating or adjusting the stroke or throw of the feed-water pump I and fuel-pump C^5 according to the distance of the apparatus from the ground, so as to ensure its moving forward at any predetermined height above the ground when driven at the desired velocity. The said pumps are worked by means of the lever O fixed upon a rock-shaft O^1 on which is also fixed a short arm O^2 (Figure 18) which is connected to the pump-rods in a manner substantially similar to that described in the said former Specification. On the long arm of the lever O is mounted a sliding block or sleeve V, which is connected by means of the rod or link L^4 to the crank-pin L^3 of the crank L^2, as indicated in Figure 2.

I provide for the automatic adjustment of the said sliding block V towards and away from the fulcrum of the arm or lever O according to any variations of the atmospheric pressure due to the rising or falling of the apparatus in the air. For instance I arrange, in the said arm or lever O, which is made hollow or tubular for the purpose a screw-threaded spindle W. This spindle is supported in suitable bearings O^3 in the ends of the arm or lever O, and the said spindle works in a correspondingly screw-threaded nut V^1 which is connected with the said sliding block or sleeve V by means of a screw V^2 arranged to work in a horizontal slot O^4 in the said arm or lever, so that the said nut, while restrained from rotation about its axis, is free to move longitudinally. W^1 is a bevel or mitre wheel formed or fixed on one end of the screw-spindle W and geared with another bevel or mitre wheel X, which is formed or fixed on a spindle X^1 supported in a suitable bearing in a plug O^5 secured in one end of the hollow rock-shaft O^1, in the interior of which the said bevel or mitre wheels are situated. X^2 is a toothed wheel which is firmly fixed on the spindle X^1, and to which intermittent rotary motion is imparted in one or the other direction during the oscillating movement of the arm or lever O, through the medium of a lever Y pivoted upon a pin or stud Y^1.

One arm of the lever Y is provided with a double or two-armed pawl Y^2, which is adapted to engage with the toothed wheel X^2. The other arm of the said lever Y is acted upon by a spiral spring Y^3. The arm of the said lever Y which carries the pawl Y^2 is connected by means of a rod or link Y^4 with one end of a circular metal box or chamber Z having corrugated ends like that of an aneroid barometer. Y^5 is a thumb-screw for regulating the tension of the spiral spring Y^3.

The operation of this regulator is as follows, *viz.*:—If the machine, after it has been moving in a horizontal direction, commences to move downward, by reason of any change in the conditions under which it is working, the increased barometric pressure will, by acting upon the said box or chamber Z, turn the said lever Y about its pivot in the direction indicated by the arrow in Figure 19, and thus cause the upper arm of the pawl Y^2 to engage with the toothed wheel X^2 as shown. In the oscillation of the arm or lever O, the said pawl will then prevent movement of the wheel X^2 about its axis in one direction, whilst permitting such movement in the other direction, the pawl engaging with the teeth of the wheel X^2 when the latter is moved in one direction and being disengaged therefrom when the said wheel is moved in the other direction. It is obvious that, while the wheel X^2 and consequently the wheel X are thus held from rotation about their axis, the wheel W^1 and screw-spindle W, while moving upward with the arm or lever O, will, by reason of the engagement of the said wheel W^1 with the wheel X, be turned about their axis, in the proper direction to move the sliding-block or sleeve V along the arm or lever O towards the fulcrum thereof, thus increasing the stroke of the pumps and consequently augmenting the quantity of steam generated in the boiler and increasing the speed of the engines so that the machine will rise. Should the machine rise above the desired height, the decrease of barometric pressure will permit the movement of the lever Y by the spring Y^3 so as to cause the lower arm of the pawl Y^2 to engage with the toothed wheel X^2; then, in the oscillating movement of the arm or lever O, the screw-spindle W will be turned in the reverse direction, so as to move the sliding block or sleeve V along the said arm or lever O away from the fulcrum thereof, thus diminishing the stroke of the pumps and consequently the speed of the engines and causing the machine to descend as required.

The screw-threaded portion of the spindle W is preferably made of such length that, should the turning of the screw in either direction be continued so as to bring the sliding block or sleeve V to either end of its desired stroke or movement, the nut V^1 will be moved out of engagement with the said screw-threaded portion of the spindle, but its re-engagement therewith will be automatically effected when the spindle is rotated in the reverse direction. W^2, W^2 are suitable springs which are arranged within the arm or lever O and around each end of the screw-threaded spindle W. When the nut V^1 moves out of engagement with the screw at either end thereof, the corresponding spring W^2 will be compressed and will, by its reaction, automatically effect the re-engagement of the said nut with the screw when the direction of movement of the latter is reversed. I thus provide for limiting the movement of the block V on the lever O.

In another form or modification of my barometric regulator, the lever connected with the pumps is curved and the sliding block thereon is attached to an arm coupled to a disc-crank on the driving-shaft. The said arm is also coupled to a toothed wheel fixed upon another shaft. A vibrating lever is provided at one end with a slot in which works a pin or stud fixed in the aforesaid disc-crank. Two rack-bars are coupled to this lever, on opposite sides of the fulcrum of the said lever, and are adapted to engage with opposite sides of the said toothed wheel. These rack-bars are coupled to a rod arranged to be moved by the barometer so as to bring one of the said rack-bars into engagement with, and simultaneously disengage the other rack-bar from the said toothed wheel. Suitable means are provided for adjusting the regulator for any predetermined height.

The load of fuel and water will necessarily diminish while the machine is in use, and, if it is desired that the machine should travel along at any predetermined height above the ground, the pressure in the boiler must be diminished as the load becomes less.

My improved barometric regulator above described will accomplish this result very effectually.

In Figure 21, I have shown one form of my improved steam-regulator. The mechanism for varying the length of stroke of the pumps is substantially similar to that of the barometric regulator above described with reference to Figures 18 to 20. Instead of the elastic box or barometer, however, I employ a disc or piston Z^1 which works in a cylinder or casing Z^2 and is arranged in combination with a flexible diaphragm Z^3, and to which is coupled the connecting-rod or link Y^4. It will be seen, however, that this connecting-rod is coupled to the arm of the lever Y to which the spring Y^3 is connected instead of to the other arm or double pawl. The space beneath the said diaphragm is in communicationwith the steam-space of theboiler or generator. through a suitable pipe Z^4, so that any increase of the steam-pressure will raise the said diaphragm Z^3 and consequently also the disc or piston Z^1, and thus move the lever Y so as to bring the upper arm of the pawl Y^2 into engagement with the toothed wheel X^2. Any decrease of the steam-pressure will permit the movement of the diaphragm Z^3 and lever Y under the action of the spring Y^3 so as to bring the lower arm of the pawl Y^2 into engagement with the said toothed wheel X^2. The said wheel is so connected with the sliding block or sleeve V that the latter will be moved along the arm or lever O towards or away from the fulcrum thereof substantially as above described, according to variations in the steam-pressure in the boiler, so that, when the pressure in the boiler increases or decreases, the stroke of the pumps will be shortened or lengthened as required.

It is not desirable that the exhaust-steam from the engine should be used for blowing the fire, because the water would, under such circumstances, be very soon evaporated. It is, consequently, necessary to provide other means for promoting the combustion of the fuel, and to condense the steam without permitting its escape into the atmosphere. I, therefore, construct the generator with an air-receiver so arranged that the forward motion of the machine will cause air to enter below the burners and be forced upward between the tubes of the generator, the heated air and products of combustion escaping at the top of the generator through the uptake or chimney C^1.

I find it advantageous, for the purpose of starting the machine, to employ rails as hereinbefore mentioned, whereby the machine may be held down while moving forward. For this purpose, two pairs of rails are suitably arranged one above another so that the wheels F on both sides of the machine can run freely against either the upper or the lower rails. I am thus enabled to ascertain, before the apparatus rises into the air, the exact inclination of the kite or aeroplane B requisite to ensure the rising of the apparatus when driven forward at the desired velocity by the propellers. For this purpose, I start the machine and observe whether the wheels F run in contact with the lower rails or with the upper rails, and, if necessary, I adjust the said kite or aëroplane from time to time until the said wheels run in contact with the upper rails. I can thus accurately adjust the aëroplane to the required inclination before allowing the apparatus to rise in the air.

In order to condense the steam by the cooling effect of the atmosphere, it is necessary to have a very large condenser. It is, therefore, desirable that the said condenser should, as above described, serve some other purpose besides that of merely condensing the steam. In some instances, I utilize the entire kite or aëroplane as a condenser, making the same of sheet metal secured upon a suitable framing, so that it encloses a large space the depth of which is very small. For example I make the aëroplane like a large flexible bag or chamber, and I connect the forward end thereof with the exhaust-pipe and the rear end thereof with the hot-well or directly with the suction of the feed-pump. The pressure in this condenser should be the same as that of the air outside thereof, so as to keep the bag distended and utilize the buoyancy or lifting power of the steam to counteract the weight of the apparatus. In some instances, I utilize only the forward part of the said kite or aëroplane as a condenser.

It will be seen that the machine or apparatus is so arranged that the weight of the engine-driver or person operating the said apparatus, and of the passengers upon the car, forms part of the necessary counterbalance or weight suspended below the plane of resistance, which maintains the said apparatus in the proper position.

I prefer to arrange the engines or motors D in such a manner that their cranks are 180° apart, that is to say, so that while one or the other of the pistonsof one engine is making its forward movement, the corresponding piston of the other engine will be making its backward movement, and the said engines will thus counterbalance each other whilst at work, one motion and weight being opposed to a similar motion and weight. Great steadiness in the movement of the machine results from this arrangement.

The kite or aeroplane may be made with either pivoted or fixed lateral extensions or wings.

I find it advantageous, in some instances, to provide the kite or aeroplane with a tail which can be set or adjusted to any desired angle or inclination relatively to the main portion of the said kite or aeroplane, and which will assist in controlling the movements of or guiding the machine through the air.

In the modification of my invention shown in Figures 22 and 23, the kite or aeroplane is provided at its forward end with what I term a bowsprit rudder a, and at its rear end with an adjustable tail b. The said rubber a is pivoted at a^1 and is adjustable by means of cords c for the purpose of effecting the vertical steering of the machine. The tail b is pivoted at b^1 and is adjustable for the same purpose by means of the cords d.

The forward portion of a kite or aeroplane acts with much greater efficiency, that is to say, it has much greater lifting power in proportion to its area, than the rear portion thereof, because, in the forward movement of the machine, the forward edge of the said kite enters air which has not been disturbed, whilst the rear portion of the said kite comes in contact with air to which downward motion has been imparted by the action of the forward edge of the kite. Therefore if the kite be of rectangular form and the centre of gravity of the entire machine be midway between the ends of the kite, the machine will be apt to rise unduly at its forward end and to have such an inclination given to it as will greatly impede or prevent its forward movement. The machine would,therefore,require to be very carefully manœuvred to prevent its rearing up on end, or pitching forward and backing down.

To overcome this difficulty and to ensure the maintenance of the machine in its proper position while flying through the air, I so distribute the weight in the machine that the centre of gravity is nearer to the forward than to the rear end of the kite, being situated say about two thirds of the length of the kite from the rear end thereof. I can also obtain the desired result by making the rear portion of the kite of larger area than the forward portion thereof. For instance I make the kite of triangular form, the apex of the triangle being the forward end of the kite. Or I accomplish the desired result by arranging the lateral extensions or wings at or near the rear end of the kite, as indicated by dotted lines in Figure 22. If two such wings are used, each projecting far enough on either side of the kite and of sufficient area to have a lifting power equal, or nearly equal to that of the body of the kite, it follows that any tendency to pitching in such a manner as to raise the forward end of the kite, will be prevented by the action of the air upon the wings, the forward edges of which will enter air which is practically undisturbed.

It is important to so construct the machine that if, from any cause, such as injury to the parts of the generator or motor, the action of the propellers should be suddenly arrested, the machine will fall steadily and without rocking or pitching, and not too rapidly. For this purpose, when the centre of gravity of the machine is in front of the centre of the kite, I provide for the adjustment of one or more portions of the kite in rear of the centre thereof, so that they are inclined in the opposite direction to the inclination of the main portion or body of the kite.

I find it advantageous for this purpose to so arrange the tail b that it can be turned into the position indicated by dotted lines in Figure 23, and to so arrange the lateral extensions or wings G that they also can be inclined upwards from the main portion or body of the kite.

In some instances, I make other other parts of the kite with suitable hinges or pivots so that they can be suitably inclined for the purpose of steadying the machine during its descent in the air. When these parts and the wings G, bowsprit rudder *a* and tail *b*, or such of them as are used, are properly inclined relatively to the body of the kite, the machine will, should the rotation of the propellers be arrested, descend in the air as steadily as an ordinary parachute.

It is obvious that I can somewhat further modify the construction of my improved aëronautic apparatus without departing from the nature of my said invention. For instance I can, if desired, make the kite or aëroplane with two or more lateral extensions or wings (either fixed or adjustable) on each side thereof. Any or all of the said wings may be provided with means for rapidly moving the same downward, for the purpose above specified, when the machine alights upon the ground. Other forms of propellers may be used if desired, and a single propeller may, in some cases, be sufficient for driving the machine. Moreover I can use, in my improved machine, any other convenient form of generator and motor providing the power thereof is suitably proportioned to the weight of the entire machine and its load and to the dimensions of the kite or aëroplane for the purposes of my invention. And it is evident that some of the devices above described, such as the steam-regulator, are applicable for similar purposes.

By employing liquid or gaseous fuel for heating the generator or boiler, I reduce as far as practicable the load of fuel required to be carried by the machine, and I provide for readily controlling the supply of fuel to the said generator or boiler. Moreover by providing the machine with an engine having all of its parts where practicable made hollow or tubular, I am enabled to make the machine very light in proportion to its power.

The generator and motor should be of such power in proportion to the weight of the entire machine and its load and the dimensions of the kite or aëroplane that, even when the latter is at a considerable angle or inclination relatively to the horizontal plane, the said motor can drive the machine forward with sufficient velocity to overcome the action of gravity and cause the said machine to rise in the air. The machine can then be readily controlled so as to cause it to ascend or descend either slowly or rapidly, or to travel in a horizontal plane at any desired height above the ground, as may be required.

The aërial machines hitherto constructed have been very heavy in proportion to their power, having a weight of from five hundred to one thousand pounds for each horse-power of the motor. Consequently they have failed to rise in the air.

I find it advantageous to adopt the following proportions between the power of the generator and motor, the weight of the entire apparatus and the dimensions of the kite or aëroplane, *viz.*;—The underside or operative surface of the kite or aëroplane, with the wings, tail and other extensions, has an area of about four thousand square feet; the approximate weight of the entire machine and its usual load is say four thousand pounds; and the horse-power of the generator and motor is about from two-hundred to four-hundred. It will be seen, therefore, that my aërial machine is very powerful in proportion to its weight. I do not, however, limit myself to any special proportions provided the generator and motor are, as above mentioned, sufficiently powerful to drive the machine forward with such velocity as to cause it to rise in the air when the kite is properly inclined to the horizontal plane. The inclination of the kite should be from one in thirty to one in sixty, and the machine should be driven through the air with a velocity of say upwards of sixty miles an hour, a high speed, within certain limits, being more favourable than a low speed.

It will be seen, moreover, that my improved machine is driven by power derived from a generator and motor forming parts of such machine. Therefore the power required to drive the machine can be developed so long as the supply of fuel lasts and while the machine is flying through the air. Whereas, in machines driven by compressed air or by a twisted cord of india-rubber, the energy required for driving the machine must be developed from a separate source and stored up in the machine before it is started.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I wish it understood that I claim:—

First. A machine for aërial navigation constructed with a suitable kite or aëroplane and one or more suitable propellers, and with a generator and motor of such power in proportion to the weight of the entire machine and its load that the said machine can be driven forward with sufficient velocity to overcome the action of gravity and cause the said machine to rise in the air without the aid of a balloon, when the said kite or aëroplane is properly inclined to the horizontal plane, substantially as hereinbefore described.

Second. A machine for aërial navigation, comprising a kite or aëroplane and one or more propellers, and provided with a steam generator and engines such as those described in my said former Specification No. 10,359, substantially as, and for the purposes, above specified.

Third. A machine for aërial navigation, comprising a steam generator of great power in proportion to its weight and heated by means of liquid or gaseous fuel, and one or more engines having all of the parts thereof where practicable made hollow or tubular, for the purposes above specified.

Fourth. A machine for aërial navigation, which is constructed with a kite or aëroplane, twin screw-propellers and a generator and motor adapted for driving the machine forward with sufficient velocity to cause it to rise in the air without the aid of a balloon, and which is provided with suitable means for varying the speed of the propellers, as above specified, to effect the steering of the machine.

Fifth. The combination of a kite or aëroplane having fixed or adjustable lateral extensions or wings, means for setting or adjusting the said kite to any desired angle or inclination, one or more propellers, and a suitable generator and motor, substantially as hereinbefore described and for the purposes above specified.

Sixth. The combination of the kite or aëroplane, one or more propellers, a suitable generator and motor for driving the said propellers, and a seat or platform for the driver and passenger or passengers, so arranged that the driver and passenger or passengers will form a counterbalance weight (or a part of such weight) suspended below the plane of resistance and tending to maintain the apparatus in its proper position, substantially as above specified.

Seventh. The combination of a kite or aëroplane having lateral extensions or wings and a rearward extension or tail, and means for varying the inclination of the said kite or aëroplane relatively to the horizontal plane and the inclination of the said tail relatively to the body of the kite, substantially as, and for the purposes, above specified.

Eighth. The combination, in a machine for aërial navigation, of a kite or aëroplane provided with movable wings, and suitable means whereby, when the machine alights upon the ground, the said wings will be rapidly moved downward, for the purpose specified.

Ninth. The improved device comprising the wheels, the levers or arms, the rack-bars, the pinions, the drums or pulleys and the wings connected by suitable ropes, cords or chains with the said drums or pulleys, substantially as described, whereby I provide for diminishing the shock or concussion imparted to the apparatus when the same alights upon the ground.

Tenth. In an aërial machine such as I have hereinabove described, a kite or aëroplane so constructed and arranged that it is wider at its rear end than at its forward end, or so that the area of that portion of the said kite or aëroplane in rear of the centre of gravity of the machine is much greater than that of the portion in front thereof, substantially as, and for the purposes, above specified.

Eleventh. A machine for aërial navigation, comprising a kite or aëroplane provided with lateral extensions or wings arranged at or near its rear end so as to equalize the lifting power or efficiency of the said kite or aëroplane throughout its length, as, and for the purposes, above specified.

Twelfth. The combination, with the kite or aëroplane and means for propelling it through the air, of a counter-weight which is capable of adjustment to vary the position of the centre of gravity, substantially as, and for the purposes, set forth.

Thirteenth. The improved apparatus, comprising the pulleys having the recessed bosses and the hollow spokes, for transmitting motion to the pumps from both engines or from the engine which for the time being is running at a higher speed, as, and for the purposes, above specified.

Fourteenth. A screw-propeller for an aërial machine, comprising metal tubes or sockets, in which are firmly secured wood or other spokes provided with a covering of silk or other suitable material, and which extend transversely through a hollow shaft or boss alternately in directions at right angles or approximately at right angles to each other, and are so arranged that they correspond to the desired pitch of the screw, substantially as hereinbefore described.

Fifteenth. In a machine for aërial navigation driven by means of a steam-engine, a condenser so constructed and arranged that, in the forward movement of the said machine, the action of the air upon the said condenser will effect the condensation of the steam and will, at the same time, raise or sustain, or assist in raising or sustaining the said machine in the air.

Sixteenth. In a machine for aërial navigation driven by means of a steam-engine, a condenser formed of thin metal and arranged above the feed-water pump so that the steam will be condensed by the air coming in contact with the said condenser and the water of condensation will flow from the said condenser to the pump by gravity.

Seventeenth. In a machine for aërial navigation driven by means of a steam-engine and one or more screw-propellers, a condenser so constructed and arranged that the action of the air thereon will effect the condensation of the steam, and, in the forward movement of the machine, the air to be subsequently acted upon by the propeller or propellers will be drawn forward by the said condenser, for the purpose above specified.

Eighteenth. The kite or aëroplane constructed with hollow rods or tubes and so arranged in combination with the engine or motor that the said rods or tubes, or some of them, serve as the condenser, substantially as described.

Nineteenth. A condenser consisting essentially of hollow rods or tubes connected together by wide flat or film tubes, substantially as, and for the purposes, above specified.

Twentieth. The kite or aëroplane connected with the supports or extensions of the main frame or car, substantially as described, in such a manner as to form fluid-tight joints whilst permitting the angular adjustment of the said kite or aëroplane, for the purposes above specified.

Twenty-first. The main frame or car of the machine constructed of hollow rods or tubes so arranged that the said tubes, or any desired number thereof, serve as the steam and exhaust pipes of the engine or motor, substantially as described.

Twenty-second. A barometric regulator so constructed that it will control the movement of an aërial machine by varying the supply of fuel or of water and fuel to the steam generator or boiler of the said machine, for the purpose above specified.

Twenty-third. The improved barometric regulator constructed substantially as described with reference to Figures 18, 19 and 20 of the drawings and operating as, and for the purposes, above specified.

Twenty-fourth. A steam-regulator so constructed that it will vary the stroke of the fuel-pump or of the feed-water and fuel pumps of a boiler according to variations in the pressure of the steam in the said boiler, for the purpose above specified.

Twenty-fifth. The improved steam-regulator, comprising the disc or piston and the flexible diaphragm connected with the mechanism for varying the stroke of the pump or pumps, substantially as described with reference to Figure 21 of the drawings, for the purpose specified.

Twenty-sixth. A regulator for the purposes above specified, comprising a rocking arm or lever connected with an engine or motor by means of a rod or link coupled to the said arm or lever by a joint which is movable to and fro upon the said arm or lever, and suitable means whereby, in the oscillating movement of the said arm or lever, the said joint may be automatically moved in one or the other direction thereon to vary the stroke or movement thereof, substantially as set forth.

Twenty-seventh. The modification of my regulator wherein I employ the toothed wheel, the vibrating lever and the rack-bars adapted to engage with either side of the said toothed wheel, substantially as, and for the purposes, above specified.

Twenty-eighth. A machine for aërial navigation, comprising a generator or boiler so constructed and arranged that the supply of air to the furnace thereof will be augmented by the motion of the said machine in flying through the air.

Twenty-ninth. The improved method of providing for the adjustment of an aërial machine before its ascent into the air, by the use of rails whereby the machine, while moving forward, is held down, substantially as, and for the purposes, set forth.

Thirtieth. A kite or aëroplane constructed in the form of a bag or chamber so that it will serve also as a condenser substantially as, and for the purposes, above specified.

Thirty-first. A machine for aërial navigation such as I have hereinabove described, wherein suitable provision is made for steadying the machine during its descent in the air should the action of the propellers cease, substantially as hereinbefore described.

Thirty-second. The combination, with the body of the kite or aëroplane, of a rearward extension or tail which can be set or adjusted for the purpose of steadying the machine while descending, substantially as hereinbefore described with reference to Figures 22 and 23 of the drawings.

Thirty-third. The modification of my improved machine for aërial navigation, wherein I employ an adjustable forward extension or bowsprit rudder, with or without an adjustable rearward extension or tail, substantially as described with reference to Figures 22 and 23 of the drawings for the purposes above specified.

Thirty-fourth. The modification of my improved machine for aërial navigation, wherein I employ a rudder arranged in rear of the propellers, substantially as described with reference to Figure 24 of the drawings.

Thirty-fifth. The improved machine constructed substantially as described with reference to Figures 1 to 17 of the accompanying drawings and operating as, and for the purposes, above specified.

Dated this 18th day of August 1890.

HIRAM S. MAXIM.

Haseltine, Lake & Co.,
45, Southampton Buildings, London, Agents for the Applicant.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.
[Wt. 39—50/6/1909.]

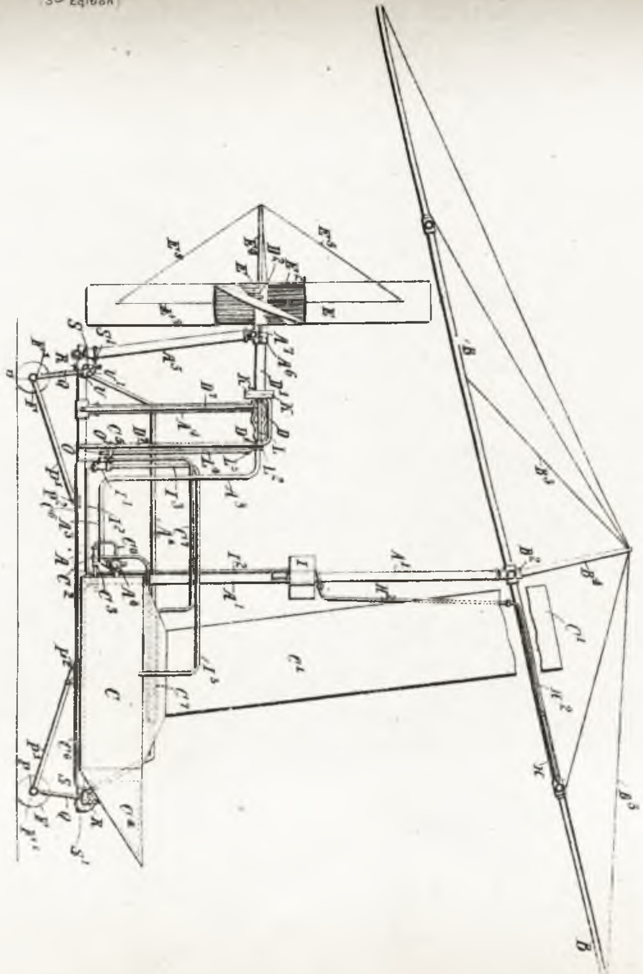

Fig. 2.

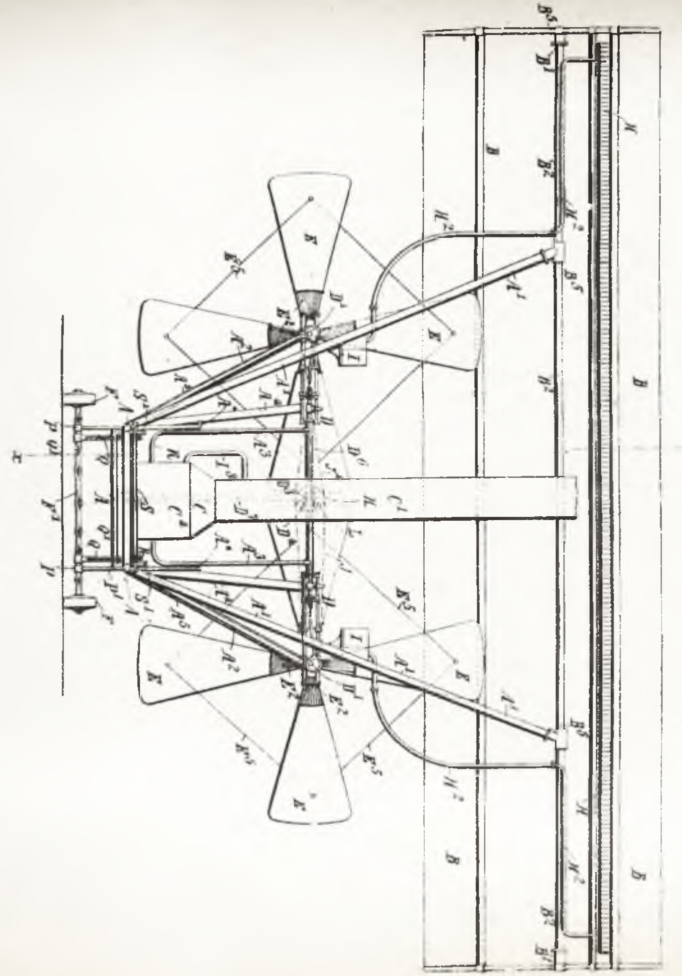

Fig. 1.

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Fig. 3.

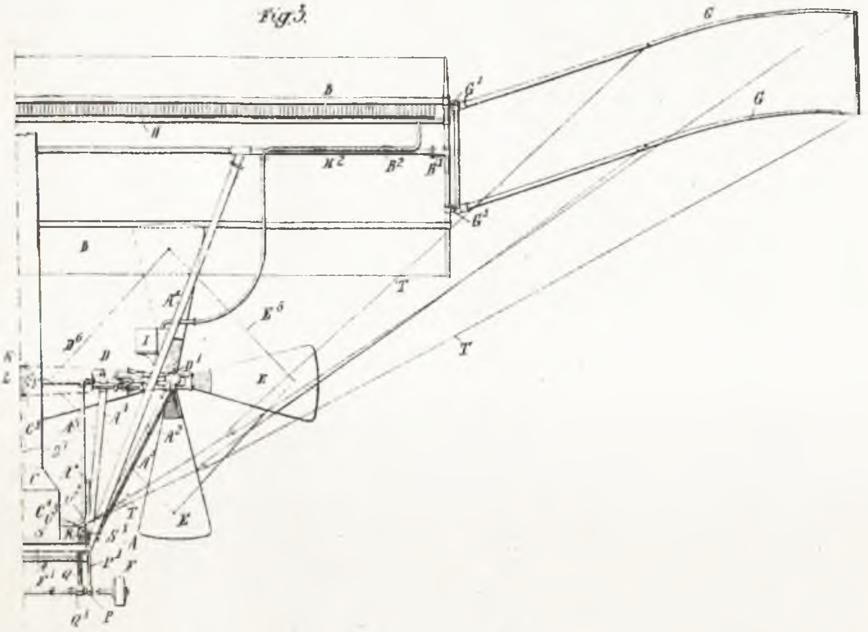

Fig. 4.

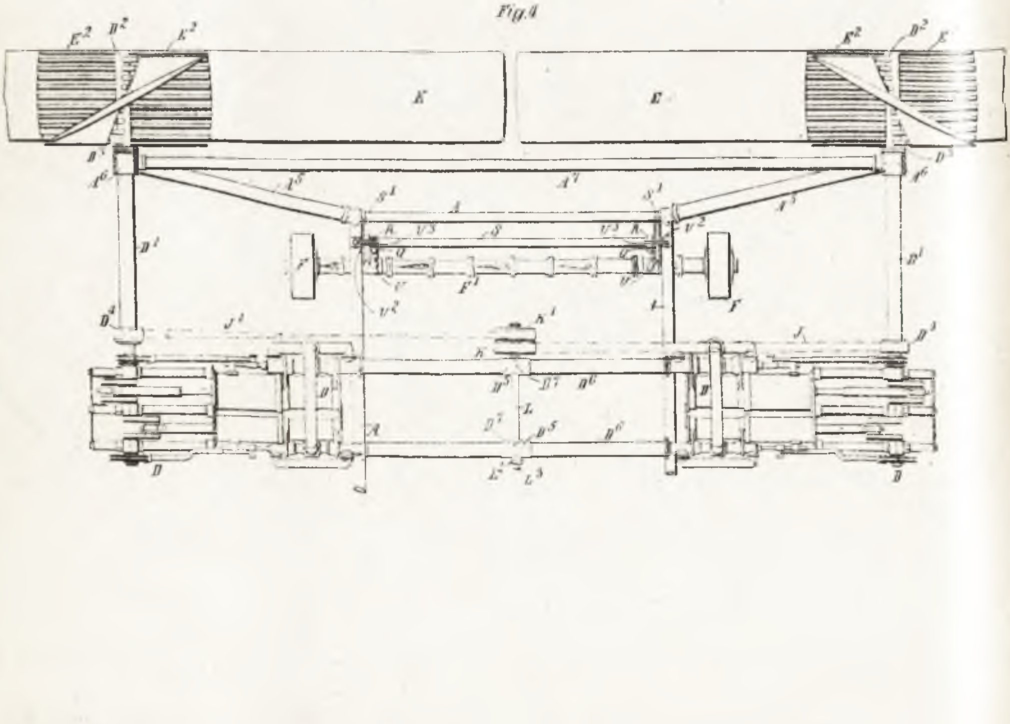

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Fig. 5.

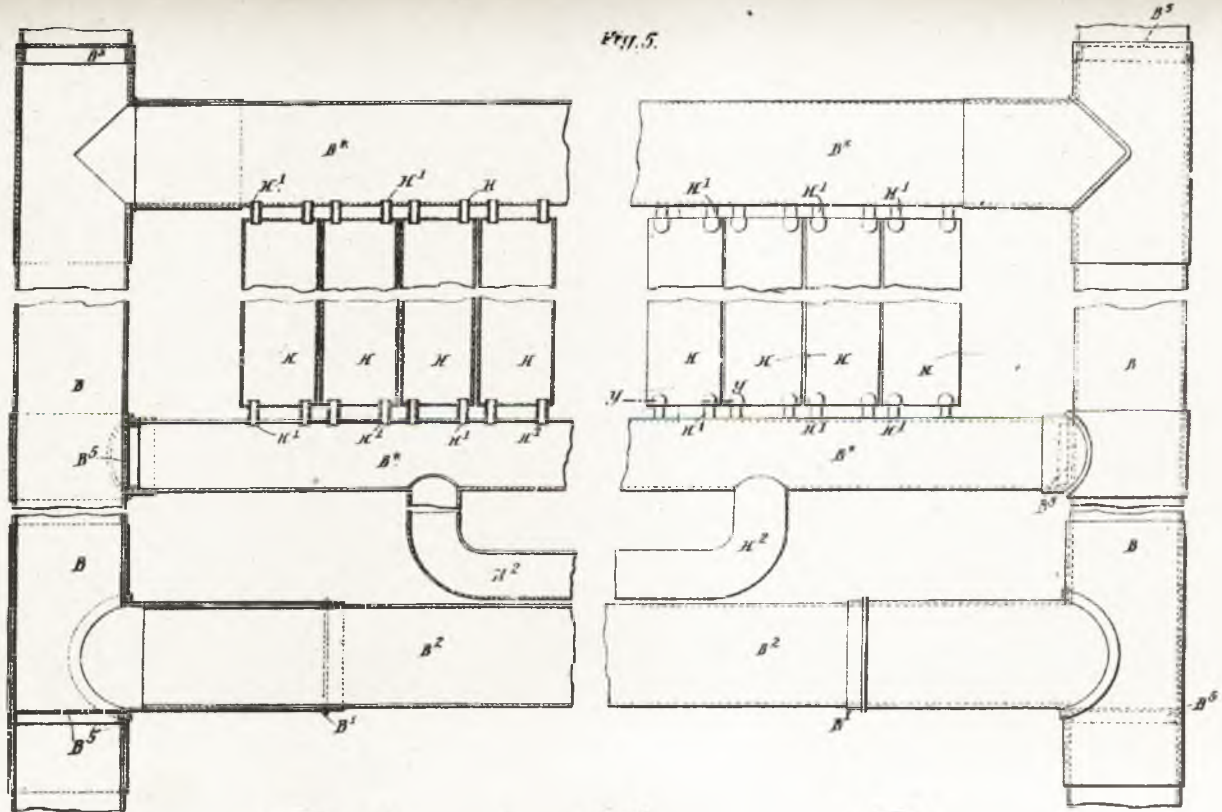
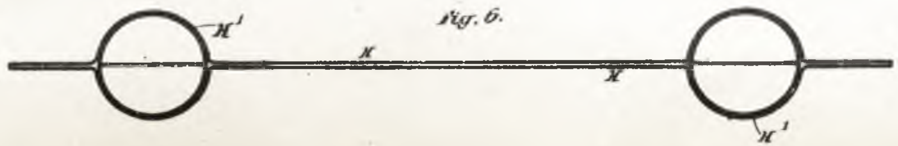


Fig. 6.



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(3rd Edition)

Fig. 7.

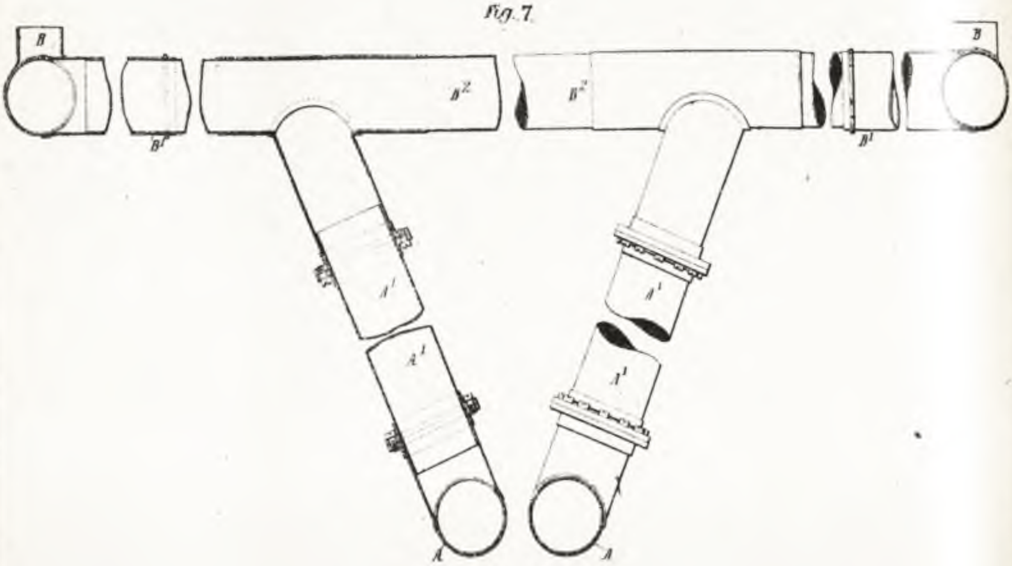


Fig. 8.

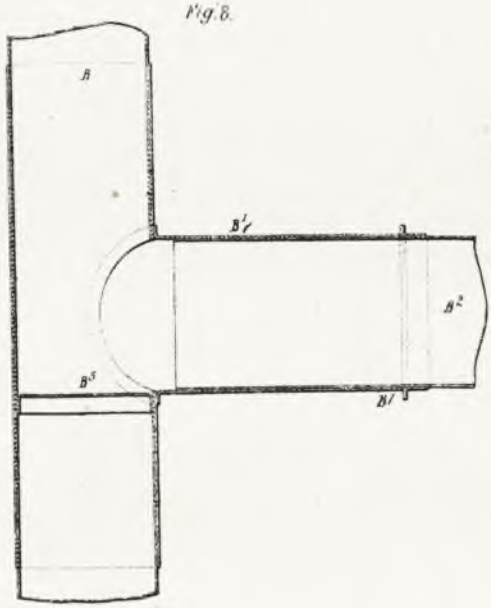
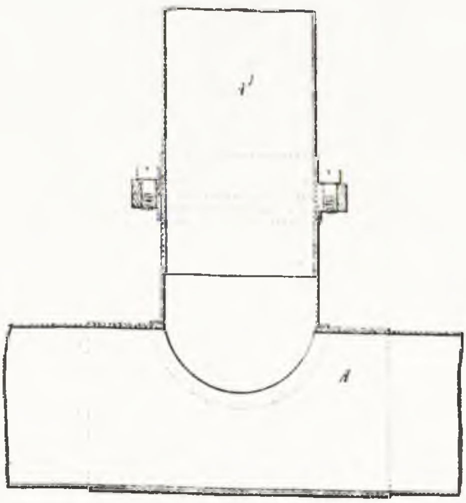


Fig. 9



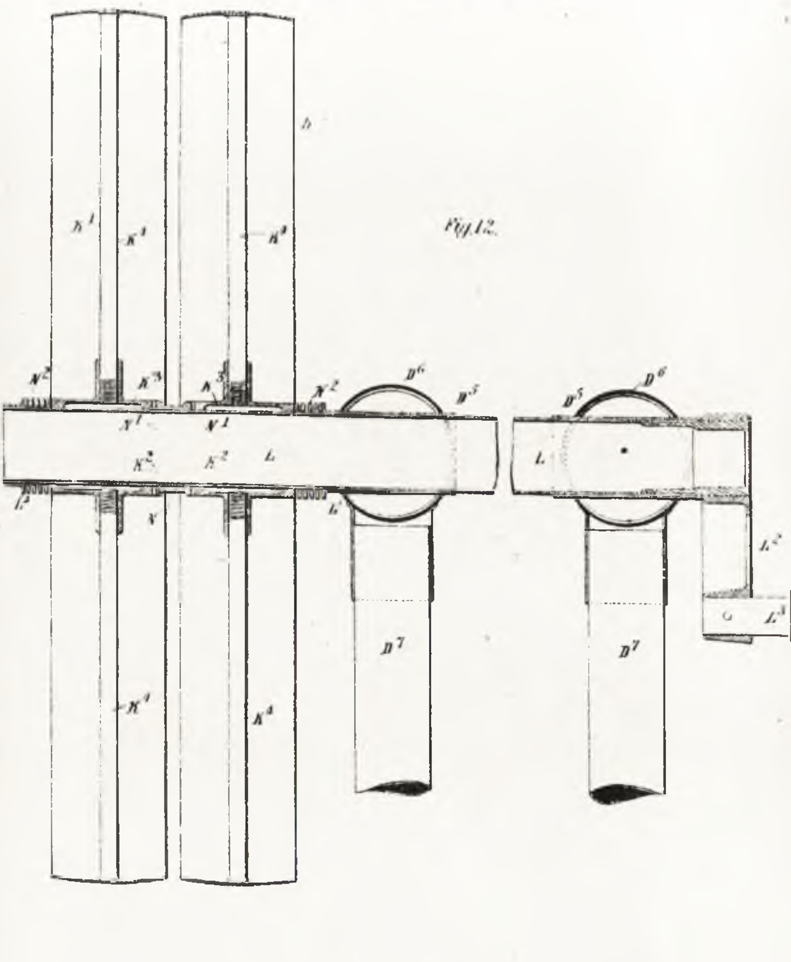


Fig. 12.

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Fig. 10.

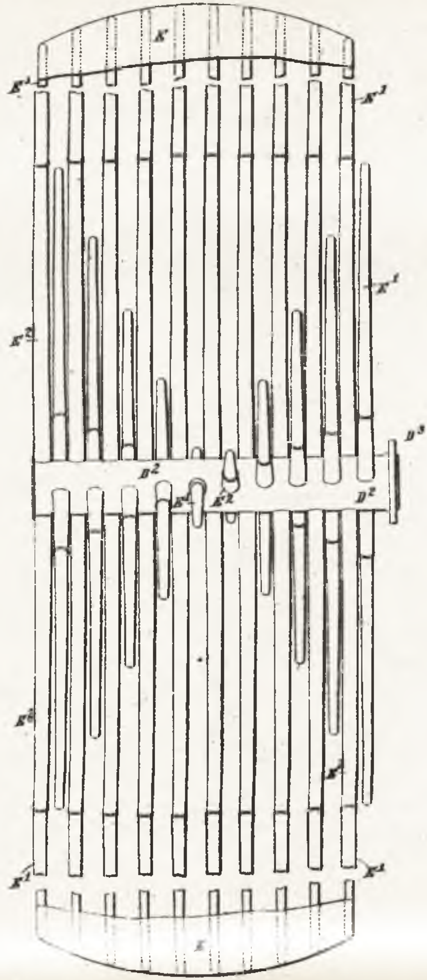
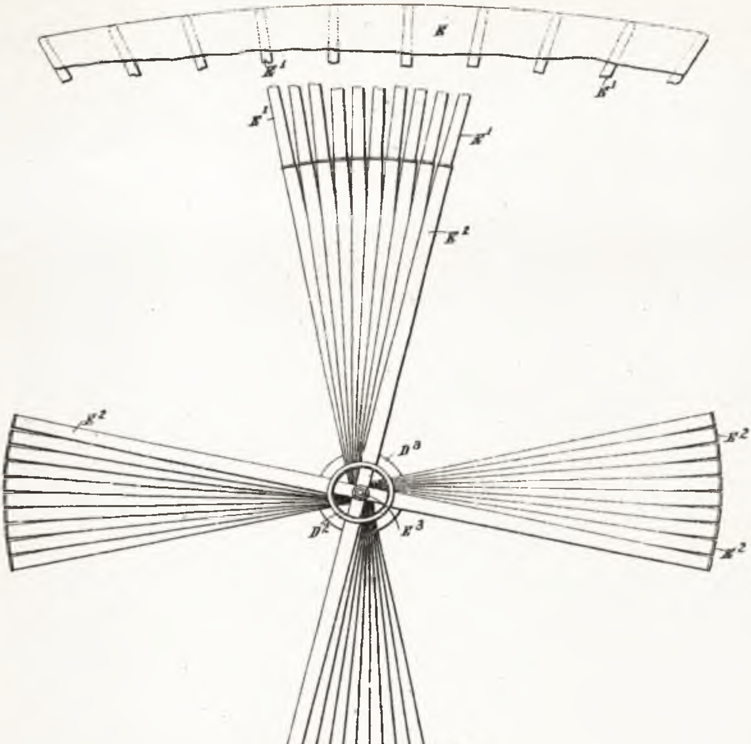


Fig. 11.



A.D. 1889. Oct. 25 N° 16,883.
MAXIM'S COMPLETE SPECIFICATION.
(3rd Edition)

(12 SHEETS)
SHEET 7.

Fig. 15.

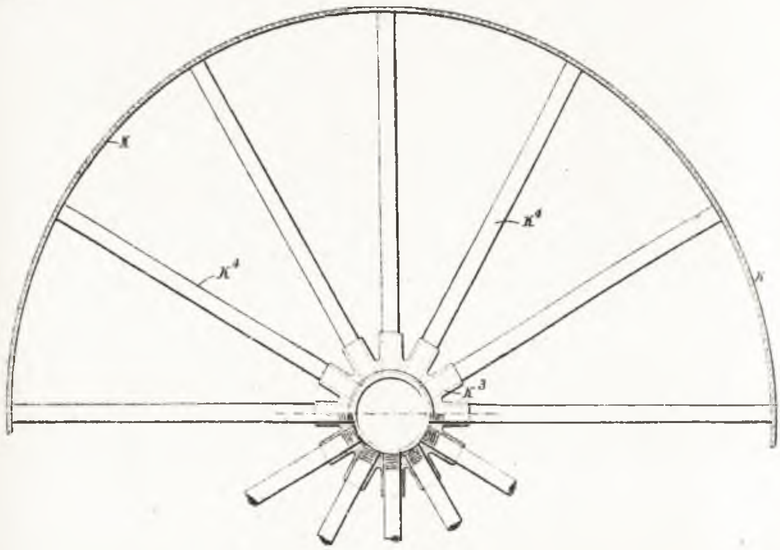


Fig. 14.

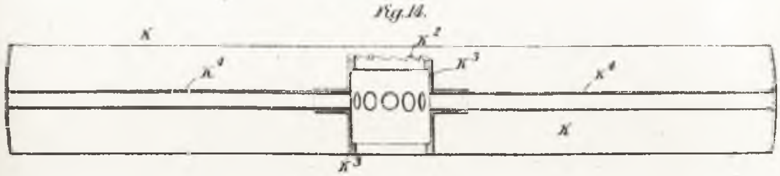
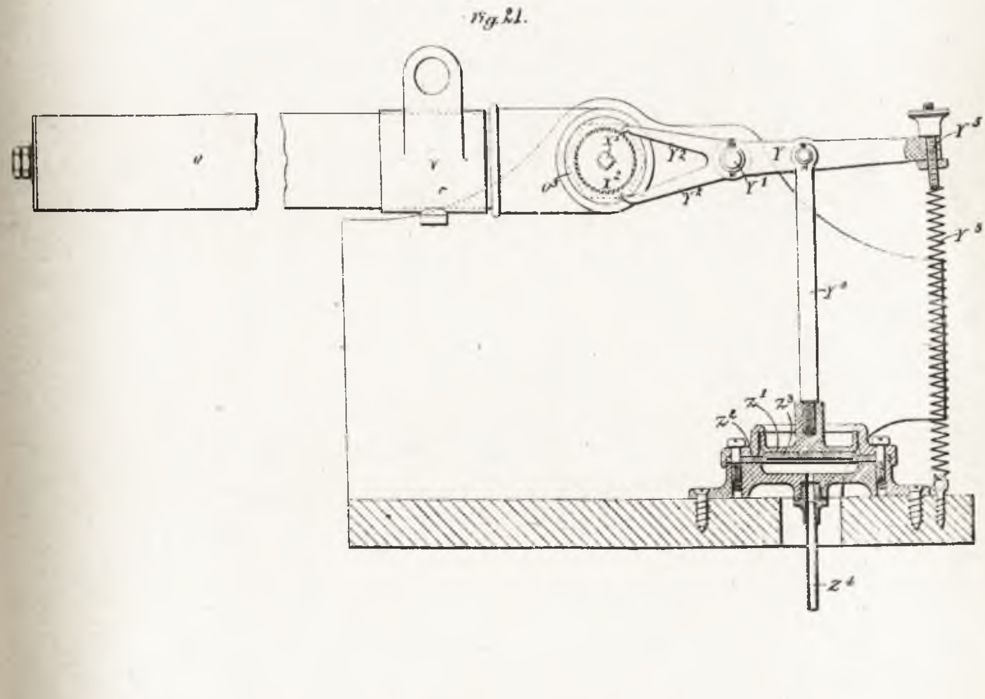


Fig. 21.



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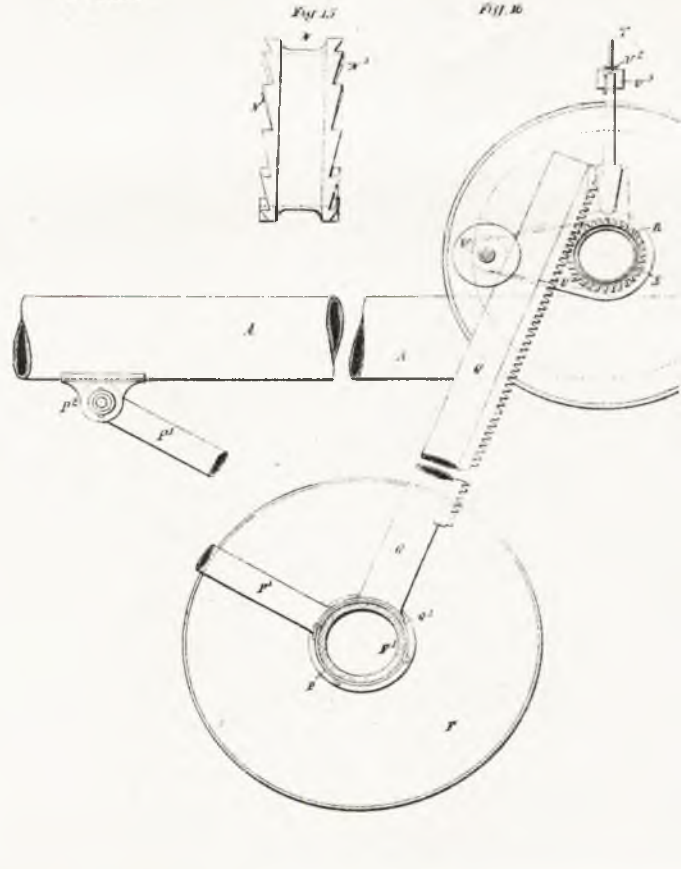

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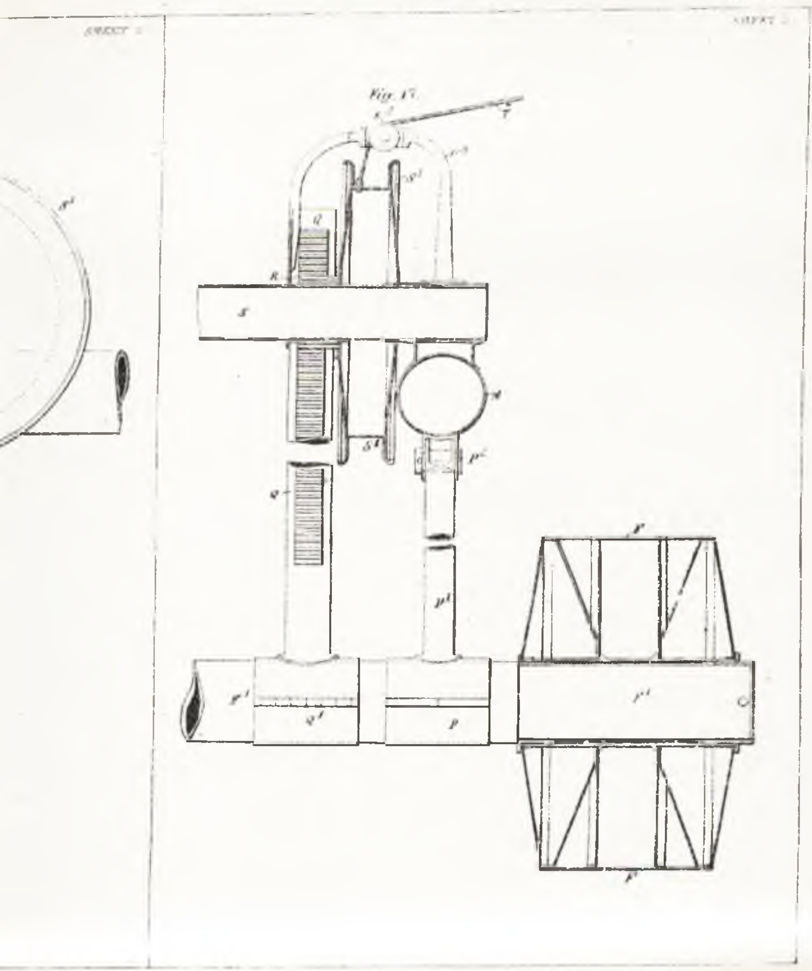
Fig. 17.

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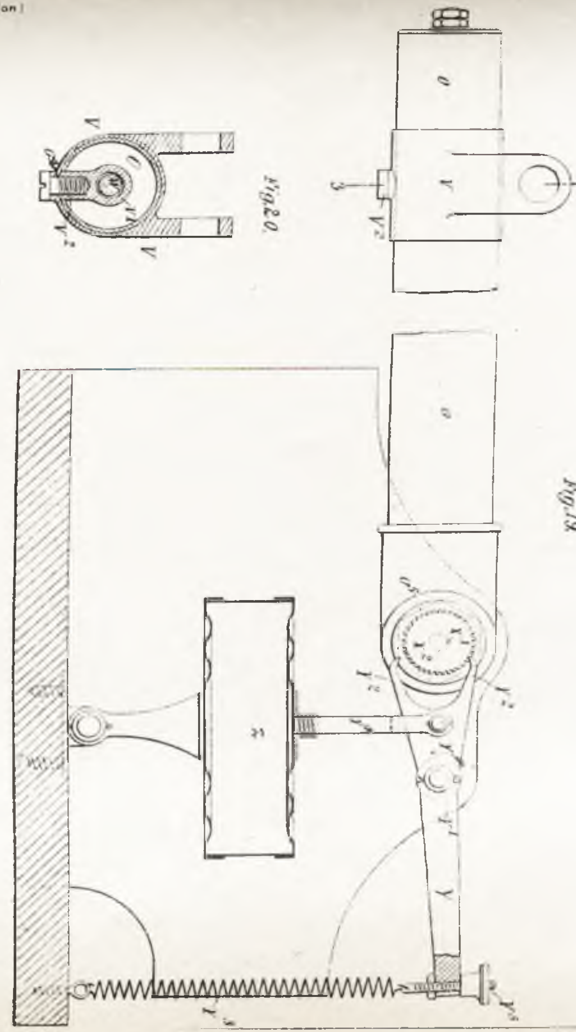
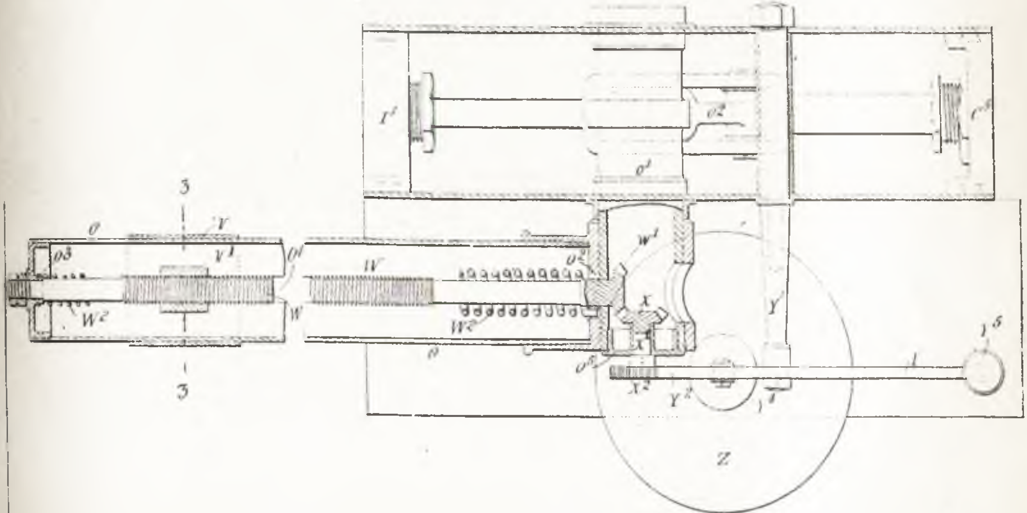


Fig. 20.

Fig. 19.

Fig.18.



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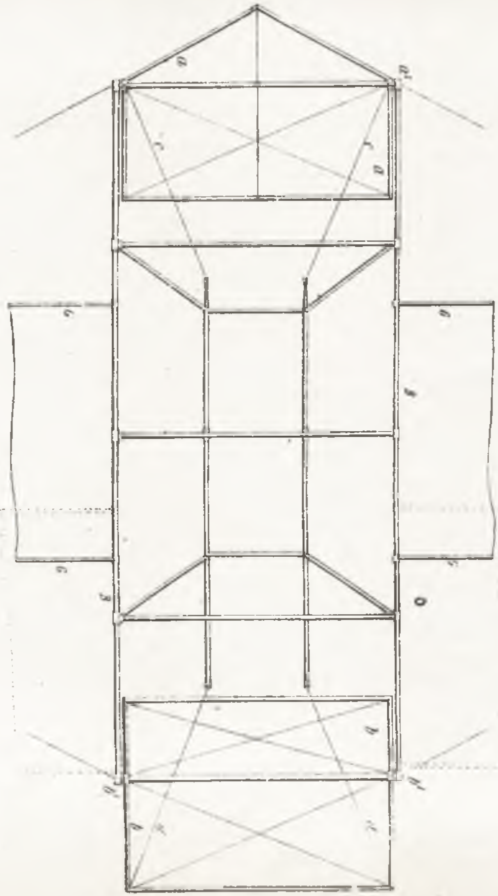

FIG. 22.

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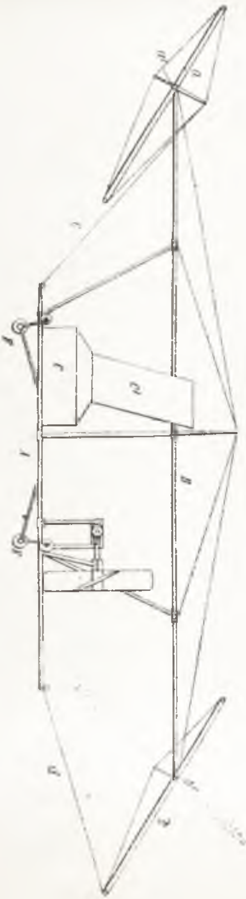
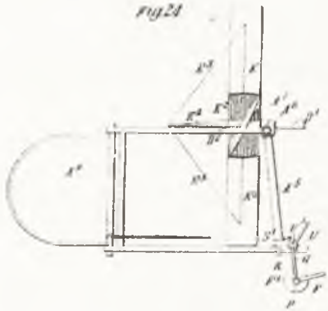


Fig 23

SHEET 12

Fig 24



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[Fifth Edition.]

N° 19,228 A.D. 1891

Date of Application, 6th Nov., 1891
Complete Specification Left, 6th Aug., 1892—Accepted, 24th Sept., 1892

PROVISIONAL SPECIFICATION.

Improvements in and relating to Aeronautic Apparatus.

I, Hiram Stevens Maxim, of Stonyhurst, Bexley, in the County of Kent, Mechanical Engineer, do hereby declare the nature of this invention to be as follows:—

My invention relates to aeronautic apparatus and to generators for use therein, and its chief object is to improve the construction and increase the safety and efficiency of apparatus for aërial navigation, such as I have described in the Specification of former Letters Patent granted to me and dated 25th October 1889, No. 16,883.

One feature of my present invention is an improved construction of the frame-work of the aerial machine. In such a machine, it is necessary to provide a frame-work having great strength and size combined with very little weight, and the centre of gravity should be considerably below the surface to which the lifting force is applied. In my improved frame-work, I employ two or more vertical trusses, in each of which there are two members, one above and another below the engines or motors and just sufficiently far apart to allow the screw-propellers, to turn. The two trusses and the two engines or motors are, moreover, just sufficiently far apart to allow the screw-propellers to rotate without touching each other. The vertical struts and diagonal braces of these trusses are made of tubing, preferably oval in transverse section. They are connected in such a manner that there is a free passage through them in every direction for the exhaust steam or other vapor from the engines. The floor on which the boiler or generator rests and on which the operator and passenger or passengers are carried is placed between the two lower members of the trusses. Attached to each end of the upper members of the trusses are two adjustable aëroplanes or horizontal rudders for the purpose of maintaining the machine "on an even keel" or at any desired inclination. By arranging these trusses one in front of each propeller, I ensure that the air disturbed by the forward movement of the framework shall be acted upon by the propellers.

A body moving quickly through the air is liable to very sudden and erratic movements. For instance, if a plane is moving forward through the air at a slight angle or inclination and at a high velocity, should the forward part of the plane become slightly tilted upward, the said plane will be lifted much more rapidly, and will also have a tendency to tip or tilt still further in the same direction. It is, therefore, very difficult to cause a plane to move straight through the air, especially when the said plane is inclined so as to cause it to rise in the air.

Another important feature of my present invention is the provision of automatic apparatus which will instantly correct the slightest variation in the angle or inclination of the plane while travelling through the air. For this purpose, I provide a peculiar kind of governor or regulator operated by a gyroscope and attached to the aforesaid two rudders or to other suitable devices for maintaining the apparatus level or at any desired inclination.

The said gyroscope is driven by steam or vapor, or by electricity, or in any other convenient manner. It is connected with an equilibrium or other suitable valve in such a manner that any tilting of the machine relatively to the position of the gyroscope, operates this valve to admit steam or other vapor under pressure to a cylinder, to act on a piston which pulls in or lets out cords or ropes so as to change the angle or inclination of both forward and after rudders, in such a manner as to keep the main aëroplane level or at any predetermined angle or inclination.

I find it advantageous to provide means whereby, as the piston moves in one

[*Price 8d.*]

direction or the other, it will not only pull in or let out the cords or ropes, but will also operate to close the valve, so that the rudders cannot be moved to either extremity of their stroke or travel by any slight pitching or tilting of the machine: the feathering of the rudders will, therefore, be effected just in proportion to the degree of such pitching or tilting, while the return of the machine to its normal position, after any deviation therefrom, will, at the same time, bring the rudders back into their normal positions.

A convenient form of apparatus for effecting this automatic closing of the valve, is constructed as follows, *viz.*:—The piston-rod is provided with an arm which is fitted to slide upon a twisted rod or upon a rod having one or more helical ribs, so that, in the movement of the piston in either direction, this rod will be caused to turn in a corresponding direction. This rod turns a screw which acts to close the valve by moving the gyroscope itself in the proper direction relatively to the valve-casing, or in any other convenient manner. This rod and the piston-rod I make hollow or tubular to obtain great strength thereof without much weight.

The apparatus is also provided with a screw which may be turned by hand to open and close the valve, and with which the apparatus can be adjusted so as to maintain the main aëroplane level or at any desired angle or inclination. And a suitable graduated scale and pointer or knife-edge are provided for indicating such adjustment.

When the gyroscope is to be driven by steam or other vapor under pressure, I find it advantageous to construct it as follows, that is to say:—The rotating part of the gyroscope consists of a tubular shaft, on which is fixed a heavy fly-wheel the spokes of which are hollow and connect the interior of the tubular shaft with nozzles on the periphery of the said wheel, so that the steam or other vapor will be discharged in jets from the said nozzles and will consequently rotate the said wheel and shaft. The said wheel and shaft are supported in suitable bearings in a casing which is suspended by means of trunnions from a bracket pivoted to and suspended from the aforesaid cylinder. The vapor under pressure is admitted into the said tubular shaft through one of the said trunnions by means of a flexible pipe or coil. The vapor is discharged from the nozzles into the said casing, whence it is conducted by a pipe into a suitable condenser.

To provide for indicating the rotation of the gyroscope, I sometimes employ a worm or tangent-screw, which is fixed on the aforesaid tubular shaft and is geared with a worm-wheel formed or fixed on an arbor or shaft carrying a disc suitably marked with complimentary colours or in any other suitable manner, so that the operator may see at a glance whether the gyroscope is rotating and the velocity of its rotation. Or I provide other suitable means for indicating whether and at what speed the gyroscope is rotating.

I provide suitable means for automatically reversing the action of the valve under the influence of the gyroscope. For this purpose I find it advantageous to employ a kind of link-motion governed by the air acting upon a fan-shaped surface or vane.

I provide the aforesaid pivoted bracket with a curved slotted arm in which is fitted to slide a block to which is coupled the connecting-rod of the valve and also a suspending link. This link is also coupled to a bell-crank-lever the vertical arm of which is attached to a small blade or vane shaped like a fan, so that, while the apparatus is travelling forward, the pressure of wind against this fan moves the connecting-rod of the valve downward, and, in this position, the gyroscope governs the machine while travelling forward. Should the engines stop and the weight of the apparatus be suspended in the air by the aëroplane while set at an angle or inclination, the force of gravity would first cause the machine to stop and then to commence to travel backwards. This backward action would bring the pressure of air on to the other side of the said fan, which would move the connecting-rod upward, and, in this position, the action of the gyroscope would be suitable to the altered conditions due to the reversal of the movement of the machine through the air. By these means, the machine will be kept "on an even keel" or at the predetermined inclination, whether while moving forward and rising in the air, or while falling after the engines have stopped. This gyroscope may also be applied to the side wings of the machine, but, as the side wings are always in a position which prevents the machine from pitching sideways, this arrangement is not absolutely necessary.

My improved machine is provided with two propelling-screws driven by engines which both take their vapor from a single source, and I may steer the apparatus by driving one screw faster than the other. This is accomplished by placing a species of damper in the main supply pipe so that it may be turned in either direction so as to close or partly close the supply to either engine as desired.

I prefer to make the screw-propellers solid. For this purpose, I make them of wood in the form of narrow strips, which are superposed so that they overlap one another, and are glued or cemented together after the manner of building up a wooden pattern for moulding the propellers of steam-ships. The said strips are, moreover held firmly together by metal clamps or flanges or in any other convenient manner. After the said strips are united as above described, the blades thus formed are worked down very thin and are prevented from splitting by gluing or cementing to their surface, cloth, linen, parchment, or similar substance. The whole is then painted or otherwise treated to preserve the wood and other substance. I provide the blades with stiffening pieces extending in a circumferential direction, and I stay the ends of the blades by wires or cords so as to overcome or resist the thrust.

I sometimes place each engine in a vertical position under the screw-shaft, so that I can connect the pumps directly with the engine and still have the pumps in a very low position on the frame of the machine.

For driving the engines of my improved machine, I can use either steam or the vapor of any suitable easily volatilized liquids.

I prefer to employ in the generator some liquid which boils more easily than water, such for instance as ether or gasoline. The following advantages arise from the use of such liquids; the total amount of heat required for evaporating a given quantity of the liquid is less; the temperature required for producing a certain pressure is less and consequently the tubes of the generator being at a lower temperature may be thinner and still withstand the pressure; the total amount of heat carried over with the exhaust is less, consequently not so large a quantity of heat has to be removed by the condenser, that is to say, there is less work to be performed by the condenser; the generator and all the passage-ways may be made of steel with no tendency to rust in the interior and the joints may be united with easily melting solder; gasoline and similar liquids have much less tendency to foam than water, and the liquid can be separated from the vapor with greater facility than is the case with water.

My improved generator comprises a casing which, in order that it may be both light and strong, should be of cylindrical form, and between which and the fire are interposed tubes filled with the liquid or vapor. The liquid is introduced through a pipe extending into the said casing at or near its upper end. From this pipe it passes into a chamber, whence it flows into another chamber through a large number of small tubes in which it is heated. It then passes down through a pipe and nozzle into a central tube containing liquid, in which it induces the surrounding liquid to flow in the same direction, and, therefore, causes a much more rapid circulation than would be due to gravity alone. The said nozzle has a variable opening or discharge aperture so that the liquid always passes through it at a high velocity, thus inducing the liquid in the large tube to flow in the same direction. The liquid descends through the said central tube and passes therefrom through radial tubes into a ring-shaped or annular tube which is perforated to receive a large number of small tubes; the liquid then rises through these small tubes where the greater portion thereof is converted into vapor. The vapor and liquid combined enter an annular space between an outer tube and an inner casing. In flowing from this annular space into the interior of the said casing, the vapors have to pass through holes which are formed at a tangent to the surface of the said casing, they are thus caused to rotate with great velocity, and this rotation serves to throw the unevaporated liquid outward, whilst the vapor passes into the centre, where it enters a perforated vapor-tube. It is found much more efficacious to separate the liquid from the vapor by means of centrifugal action than by gravity alone. The separated liquid falls into the said central tube, whence it is again forced through the before mentioned small evaporating tubes, whilst the vapor, after passing through other heating or superheating pipes if necessary or desirable, is conducted to the engines or motors.

To ensure lightness of the generator, it is necessary to make the parts thereof very small. By reason of the great quantity of vapor passing and the small size of the chamber, some of the liquid passes over with the vapor, and, rising up with the vapor, passes through the said superheating tubes. These tubes may, however, be considered rather as a finishing series of tubes than as a superheater. The liquid in entering passes through a similar series placed immediately over the finishing series, so that the liquid, by the time it enters the boiler, may be at as high a temperature as the vapor itself. Moreover a considerable advantage is afforded by having the cold liquid enter at the top of the generator, because, in this position, the heated gases encounter the cold tubes after they have done all the work they are able to do on the highly heated tubes. They, therefore, give up a larger amount of their caloric than they otherwise would.

I propose to have the pressure on the entering liquid considerably higher than the steam or vapor pressure. The nozzle in the central tube is provided with a cone acted upon by a spiral spring which holds it tightly in the nozzle until the pressure on the liquid over and above the pressure of the vapor is sufficient to compress or extend the said spring as the case may be. In this manner, no matter whether a large or a small quantity of liquid is passing, it will escape between the cone and the nozzle with great force and it is this force striking or impinging against the other liquid which causes the rapid circulation and enables me to use much smaller and lighter tubes than would be necessary providing the circulation was due to gravity alone. The evaporating tubes are bent or curved and arranged in such a manner that they cover or line the interior of the casing, and they are also bent in such a manner as to present a very large amount of heating surface to the fire.

The generator is preferably provided with means for burning liquid or gaseous fuel, and my present invention comprises a combined pressure and thermostatic regulator whereby two systems of automatic regulation of the supply of fuel are obtained, one controlled by variations of pressure and the other by variations of temperature.

To accomplish this result, I provide an annular chamber which is filled with water or other suitable liquid. In case there should be any failure of the pumps to deliver a sufficiently large quantity of liquid into the generator, the apparatus cannot be overheated, because, so soon as a sufficiently high pressure is generated in the said annular chamber, the supply of fuel will be cut off. When however, liquid is pumped into the generator the cooling action of this liquid on the said annular chamber will reduce the pressure and allow the fuel to pass to the burner or burners.

The pressure in the aforesaid ring-shaped or annular tube is also utilized to regulate the supply of fuel to the burner or burners. The blow-pipe is for this purpose connected with two cylinders, and the valve for controlling the supply of fuel is connected by one or more levers to both pistons of these cylinders, or there may be two valves in the same fuel supply pipe operated independently of each other by the pressure of the vapor and by the pressure in the said annular chamber respectively.

This arrangement enables me to make a generator which is very strong, very light and very efficient.

As the vapors of gasoline or ether do not carry off a very large amount of heat, I prefer to keep the cylinders, valve-casing and other parts of my engine hot in order to prevent condensation. For this purpose I sometimes burn a certain portion of the vapors, or I may use heat from any other source.

The blow-pipe is provided with a lever and spring in such a manner that, by moving the lever and securing it, any desired pressure may be maintained. When the exhaust vapors leave the engine, they pass through the members and braces of the trusses which constitute the sides of the aërial machine and through a series of small tubes, and, as the liquids are condensed and cooled, they may be again pumped through the generator. In using gasoline, it is found that each time it is worked over, a small quantity of vapors which are not easily condensable are produced, gasoline not being a homogeneous body. I utilize these non-condensable vapors by burning them in the furnace; or I may supply the burner or burners altogether from the exhaust vapor, or I may employ for the larger part or portion of my fire, the vapors of some heavier petroleum which is cheaper than gasoline, and in case this is done a certain amount of the heat which escapes through all the series of tubes may be utilized for generating vapors from this heavier petroleum.

When a compound engine is used I provide a by-pass around the high pressure cylinder so as to allow if necessary more steam or vapor to enter the large low pressure cylinder that can be discharged from the smaller high pressure cylinder but instead of allowing it to pass through a relief valve simply, I provide a species of injector so that portion of the force exerted by the vapor in passing from a high to a low pressure is utilized in pushing the steam or vapor along in the pipe that leads from the high to the low pressure cylinder, that is to say this pipe is made into an injector the suction being the exhaust of the high pressure cylinder and the discharge the inlet to the low pressure cylinder while the inducing jet is the steam or vapor that passes direct from the boiler to the low pressure cylinder.

I sometimes make the aëroplane with a framework of metal tubes having stretched across it longitudinally a considerable number of wires, ropes or cords, which framework is covered with linen, cotton-sheeting, silk or similar material. If such material were stretched over a frame having large square or oblong apertures or panels, it would assume the form of a series of bags, and consequently a great amount of power would be required to propel it through the air. But with my improved construction, such bags as are formed will consist of long troughs extending between the said wires or cords in the direction in which the machine travels; therefore less resistance will be offered to the movement of the aëroplane through the air.

Dated this 6th day of November 1891.

D. YOUNG & Co.,
11 & 12, Southampton Buildings, London, W.C., Agents for the Applicant.

COMPLETE SPECIFICATION.

Improvements in and relating to Aeronautic Apparatus.

I, Hiram Stevens Maxim, of Baldwyns Park, formerly of Stonyhurst, Bexley, in the County of Kent, Mechanical Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This invention relates to aeronautic apparatus or air-ships and their adjuncts.

The said invention comprises improvements in the frame work of the air-ship; in means formaintaining the said ship on an even keel or at anydesired inclination; in the construction of the propellers, engines and boilers, and their adjuncts; and in combinations of these improvements as will be hereinafter fully set forth.

Referring to the drawings which illustrate my improvements,

Figure 1 is a side elevation, and

Figure 2 is a plan of my improved air-ship.

Figure 3 is a front elevation of the said ship, the fore and aft rudders hereinafter described being removed.

Figure 4 is a side elevation of the framework showing the connection of the rudders to the controlling mechanism.

Figure 5 is a plan, and

Figure 6 is an elevation, partly in section, of the said controlling mechanism drawn to an enlarged scale.

Figures 7 to 14 are detail views of the said mechanism hereinafter fully described.

Figure 15 is a view of one of the transverse frame-rods showing the methods of preventing contact of the silk therewith.

Figure 16 is a detail view on an enlarged scale of a bracket hereinafter described.

Figure 17 is a vertical central section of the boiler on an enlarged scale.

Figure 17A is an enlarged transverse sectional view of the feed-water pipe and discharge nozzle hereinafter described.

Figure 17B is a section on the line y y Figure 17A.

Figure 18 is a transverse section on the line x x Figure 17.

Figure 19 is a section of a union for one of the boiler tubes drawn to a greatly enlarged scale.

Figure 20 is a side elevation partly in section of the burner and regulator for the boiler.

Figure 21 is a plan of the same, a portion of the deflector hereinafter described being removed to show the burner tubes underneath.

Figure 22 is a section on the line x^1 x^1 Figure 21 drawn to an enlarged scale.

Figure 23 is a similar section taken on the line x^2 x^2 Figure 21.

Figure 24 is a longitudinal central section on an enlarged scale of the regulator.

Figure 25 is a plan, and

Figure 26 is an end elevation of the said regulator.

Figure 27 is a vertical central section of a two cylinder single acting engine hereinafter described.

Figure 28 is an enlarged side view of the eccentric.

Figure 29 is an enlarged section of the pump.

Figure 30 is a sectional view showing the cylinders and steam pipe connections for a compound engine with a bye-pass arranged as hereinafter described.

Figure 31 is a side elevation of a propeller, one half being shown incompleted.

Figure 31A is a section on the line y^1 y^1 Figure 31.

Figure 32 is an end view of the propeller.

Figures 33 and 34 are side and end elevations respectively of a device for indicating the lifting force of the aeroplane or kite.

Like letters of reference indicate corresponding parts throughout the drawings.

Referring to Figures 1 to 3 the frame is built up of two main side-trusses A, A constructed throughout of thin steel or other strong metal tubes suitably braced together and stayed to ensure the desired degree of strength and rigidity. a a are the bottom members of the said trusses, and a^1 a^1 are the top members; a^2 a^2 are diagonal struts which connect the said top and bottom members. The top members a^1 are connected by transverse tubes a^3 which are extended beyond the said top members, and are joined at their ends by longitudinal tubes a^4. The series of tubes a^1, a^3, a^4 forms the framework of the main aeroplane or kite hereinafter more particularly described which sustains the weight of the apparatus when in motion. a^5 a^5 are other diagonal struts which connect the bottom members a with one of the transverse tubes a^3. a^6 a^6 are other side struts connected with the top and bottom members and intended to carry the crank shaft and support the engine. These struts are well braced and stayed by transverse and diagonal braces a^7 and are further stiffened by wire guys a^8 so as to be very rigid. On each longitudinal side member a^4 is pivoted a wing a^9 which is supported at its outer end by wire guys a^{10} connected with upwardly extending struts a^{11} carried by the top members a^1. The frame work is stiffened and supported by wire guys in every direction where such supports can be conveniently applied. The diagonal struts a^2 a^3 are preferably oval in transverse section. They are connected together in such a manner that there is a free thoroughfare through them and they are utilized as the exhaust pipes connecting the engine to the condenser. The exhaust steam or other working fluid thus passes through the hollow framework to the condenser. The condensed steam or other fluid falls back from the condenser through the lower parts of the said hollow framework to the pump. The top and bottom members a a^1 of the main trusses are sufficiently far apart to allow the screw propellers to turn between them. The said top members a^1 are preferably curved as shown in Figure 1.

This construction combines great strength with little weight, and the centre of gravity of the whole machine is brought very much below the surface to which the lifting force is applied. The floor of the car is situated between and secured to the bottom horizontal members of the trusses. A hand rail is provided around the floor for the protection of the persons thereon. a^{12} a^{12} are fenders projecting on each side the ship, and to which are attached long horizontally projecting arms a^{13} which I term flotation planes. The said planes or arms are suitably stayed at their outer ends by wire guys.

Between the forward and rear ends of the top members of the side trusses are pivoted at b b to rudders B, B. These rudders each consist of a flat frame suitably stiffened by guys b^1 attached to the ends of the said frame and passing over struts b^2 projecting from near the centre of the sides of the said frame. The said rudders are tied together by crossed wires b^3 as shown so that any oscillation of one rudder about its pivot will be accompanied by a corresponding oscillation of the other rudder about its pivot. For automatically controlling the movements of the rudders I provide as follows, that is to say I connect one or both rudders by a rope or ropes b^4 Figure 4 with a device C which operates to pay out or take in the said rope or ropes and so turn the rudders as desired. The said device C is illustrated in detail in Figures 5 to 14. It comprises a cylinder c fitted with a piston c^1 and piston rod c^2, the latter passing through stuffing boxes c^3 in the cylinder ends. The said cylinder is carried by brackets c^4 suitably fixed on the car. Each end of the piston rod carries a pulley block c^5 through which the ropes b^4 are reeved. The ends of the ropes are made fast to the framework. With this arrangement any sliding movement of the piston will take up the rope at one end of the cylinder, and will pay out the rope at the other end at double the speed at which the piston itself moves. For controlling the admission of steam or other working fluid to the cylinder c, I provide an equilibrium valve c^6 which works in a valve box c^7 carried by brackets c^8 that clip the cylinder. The valve box is open at both ends and is bored accurately from end to end. c^9 c^9 are the valve faces. c^{10} c^{10} are end pieces constructed to fit the bore of the valve box accurately; c^{11} c^{11} c^{11} are parts of the valve of smaller diameter connecting the larger parts c^9 and c^{10}. c^{12} is the supply pipe for the working fluid; c^{13} c^{13} are the admission ports which communicate respectively by pipes c^{14} c^{14} with the ends of the cylinder. c^{15}, c^{15} are the exhaust ports. It is obvious that this valve is in perfect equilibrium and will therefore be easily moved with very little force. The valve faces are made to slightly overlap the edges of the admission ports. For automatically controlling the movements of the said valve I provide a gyrostatic apparatus which is constructed and arranged with its connections as follows. The gyrostat comprises a wheel d having a heavy rim and a thin web d^* mounted on a vertical axle d^1 which is arranged to rotate in bearings d^2 d^2 provided in a case d^3. The said case is suspended by trunnions d^4 d^4 from a bracket d^5 which is pivoted at d^6 see Figure 12 to a sleeve d^7 mounted on the cylinder c. The pivot pin at d^6 is arranged at right angles to the trunnions d^4 and thus the case d^3 is free to swing in all directions. The sleeve d^7 is made to be capable of sliding on the cylinder c for a purpose hereinafter described. The axle d^1, is made hollow as shown, and in the rim of the wheel are fixed two or more nozzles d^8, the apertures of which are tangential to the rim of the wheel. The nozzles may be constructed to screw into the rim and they are preferably made pointed at the forward ends so as not to offer any serious resistance to the rotation of the wheel. d^{**} d^{**} are radial thorougfares in the web d^* leading from the hollow axle d^1 to the nozzles d^8. One of the trunnions is made hollow and provided with a stuffing box d^9. d^{10} is a flexible coil of pipe coupled to the stuffing box d^9 by which steam or other working fluid is supplied to the wheel d for driving the same. The said working fluid enters through the hollow trunnion d^4 and passes down the hollow axle d^1 and then through the radial holes d^{**} and issues from the nozzles d^8 with sufficient force to cause the wheel by reaction to rotate very rapidly. d^{11} is a flexible pipe for conducting to the condenser the waste steam or working fluid which issues from the nozzles d^8.

To provide for indicating the rotation of the wheel d, I employ a worm d^{12} formed on the axle d^1, which worm gears with and drives a worm wheel d^{13}, (see Figures 13 and 14) supported in suitable bearings d^{14} provided in the casing d^3. On the end of the axle of the worm wheel d^{13} is fixed a disc d^{15}. I find it convenient and effective to mark this disc with complementary radial colour bands, so that a glance at the disc will show whether the wheel is rotating and at the proper speed or not. To the bracket d^5 is fixed a curved guide piece d^{16} in which is fitted to slide a block d^{17}. The said block is connected with the valve c^6 by a link d^{18}. The guide d^{16} is curved to a radius equal to the length of the link d^{18} so that any movement of the block d^{17} up and down in the sector when the latter is in its mid position will not affect the valve. The said guide is fixed to the bracket d^5 in such a position that its centre is opposite the pivot pin d^6 of the bracket d^5. For controlling the position of the block d^{17} in the guide d^{16} I connect the said block by a link e with one end of a bell crank lever e^1 pivoted at e^2 to a bracket e^3 which clips the cylinder c. This bracket is shown in side view in Figure 11. The other end of the said bell-crank lever stands upright or nearly so and carries a vane e^4 which when the air-ship is moving forward is blown back by the air and thereby moves the block d^{17} to one end of the guide piece d^{16} and maintains the block in that position so long as the air-ship continues to move forward. Should however the air-ship commence to move back, the aforementioned vane will be blown forward, and the bell-crank lever thereby caused to move the block d^{17} to the other end of the guide d^{16}. In this position of the said block, the gyrostat will have just the reverse action upon the valve and consequently it is thereby adapted to control the air-ship whether the latter be moving forward or backward.

f is a tubular shaft carried in the brackets c^4 c^8 and having a screw-threaded portion f^1 which engages with a corresponding screw-threaded nut d^{19} formed on the sleeve d^7. By rotating the shaft f in its bearings, the screwed part f^1 is screwed in or out of the nut d^{19} and the sleeve d^7 is thus moved one way or the other on the cylinder c. f^2 is a spiral rib provided on the shaft f near one end thereof. f^3 is an arm firmly secured at one end to the piston rod c^2 and having an eye-piece f^4 which embraces and is adapted to slide on the shaft f. In the said eye piece is cut a key way f^5, see Figure 8, to fit the spiral rib f^2. If now the shaft f be prevented from longitudinal sliding movement in its bearings it follows that when the piston rod c^2 is forced in or out of the cylinder the arm f^3 acting on the spiral rib f^2 will cause the shaft f to turn in its bearings, the amount of the rotation depending on the pitch of the spiral rib and the distance through which the piston rod c^2 is moved.

The action of the above described gyrostat and its connected parts is as follows: Should the air-ship tilt either up or down from any cause, then by reason of the tendency of the gyrostat to remain in the same plane there will be a tilting movement of the cylinder c with respect to the gyrostat suspended therefrom, which will have the same effect on the valve as tilting the gyrostat with respect to the cylinder. The result is that the valve c^6 will be moved one way or the other and steam or other working fluid will be admitted to one end of the cylinder c thus driving the piston c^1 towards the other end of the said cylinder. This movement of the piston operates the rope or ropes b^4 paying out rope at one end and taking in rope at the other and so turning the rudders B, B and altering the inclination thereof that the tilting of the air-ship is immediately checked. This movement of the piston c has moreover the effect of turning the shaft f and thereby as above described moving the sleeve d^7 bodily on the cylinder. Such movement of the gyrostat as a whole carries the valve c^6 with it, and the direction of movement is such that the said valve is caused to close the admission port. It is obvious that if the air-ship is but slightly tilted, the valve c^6 will be but slightly opened and consequently a very short movement of the piston c^1 will suffice to close the valve again while on the other hand if the air-ship is tilted through a greater angle, the valve will be opened wider, and a greater movement of the piston will be required to close it again. Consequently the adjustment of the rudders is proportional to the tilting of the ship. The rudders having now been moved from their original positions there arises a tendency for the air-ship to tilt in the opposite direction and consequently the gyrostat is caused to move the valve so as to open the other admission port and admit the working fluid to the other end of the cylinder, thus moving the rudders back and at the same time re-adjusting the position of the sleeve d^7 on the cylinder c. In this manner a balance is maintained by the gyrostat, and the air-ship is kept on an even keel or at any angle of inclination to which it may have been set.

It is desirable that the air-ship should be able to ride with its frame set at different degrees of inclination. I provide for this by a simple device for adjusting the position of the shaft f. This device comprises a bolt or pin f^6 fixed in the end of the shaft f and having mounted thereon a screw-threaded sleeve f^7. The said sleeve works through a corresponding screw-threaded eye f^8 formed in the bracket f^9 which supports the end of the shaft, and it is provided with a crank handle f^{10} by which it may be turned to screw it through the said eye piece for the purpose of adjusting its position therein. A side view of the bracket f^9 is shown in Figure 10. By this means the shaft f is moved longitudinally and the initial position of the gyrostat and consequently of the valve c^6 is adjusted as required. It is clear that the inclination of the air-ship as it travels through the air will be affected by this initial adjustment of the valve c^6 inasmuch as the distance it is thrown out of the central position determines the amount the gyrostat must tilt with reference to the ship to bring the valve back to the central position, and therefore it follows that by suitably adjusting the position of the shaft f by means of the handle f^{10} the air-ship can be maintained if desired on a level keel or at any desired angle of inclination. I can modify the arrangement or construction of the adjusting mechanism in many ways, all that is necessary is to provide for adjusting the longitudinal position of the shaft f and for locking the said shaft when adjusted so as to prevent longitudinal movement when working without interfering with the rotation of the said shaft. The eye piece f^8 is split at the top as clearly shown in Figures 5 and 10 and is provided with a tightening screw f^{11}. By turning the said screw the sleeve f^7 can be locked tight and prevented from accidental rotation. I provide a scale f^{12} Figure 5, fixed on the bracket f^9, and I fix a knife-edged disc f^{13} on the shaft f the edge of the said disc turning in close contact with the scale. By this means and using a properly marked scale I am enabled to set the machine beforehand to fly at any desired inclination.

It is well known that any moving body travelling through a resisting medium such as the air has a tendency to present its broadside to the direction in which it is travelling. A boat for example when drifting down a stream always tends to present its broadside to the stream and would always do so if not checked. In my air-ship the rudders tend to present their broadsides to the direction of motion but they are continuously and automatically checked, and maintained in the desired position by the controlling mechanism above described. This will appear from the following consideration. Suppose one of the rudders moves a little from its mean position, then by reason of the connection with the piston rod c^2 the latter will be moved one way or the other, and will turn the shaft f. The gyrostat is thus moved along the cylinder c and opens the valve c^6 thereby admitting the working fluid to the cylinder. The connections are so arranged that the working fluid is admitted at the end of the cylinder towards which the piston has been moved by the turning of the rudder and consequently the piston is forced back again and the rudder immediately returned to its initial or normal position. This return of the rudder operates to re-adjust all of the connections just referred to and the normal state of things is thereby recovered. The recovery is thus seen to be automatic, it is moreover very quick in its action and the ship is thereby prevented from deviating materially from its course. It is thus seen that the rudders are practically locked after the adjustment of the apparatus is made and are prevented from any material deviation from their normal position.

It is obvious that the gyrostat can be arranged to be driven by electricity or in any other convenient manner.

A gyrostat may also be provided for adjusting the side wings of the air-ship but as the said side wings are always in a position which prevents or controls sideways pitching, it is not always necessary to apply such apparatus to these wings.

The main kite or aeroplane D preferably consists of a framework of thin metal tubes covered with silk. In the construction shown in the drawings there are four longitudinal tubes two of them being the two top members a^1 of the main trusses before referred to and the other two the side tubes a^4. These tubes are tied together by the transverse tubes a^3. Now it is important that the silk covering should not touch the said transverse tubes a^3 otherwise a number of hollows will be formed in the silk the curvatures of which will be very detrimental to the lifting power of the kite and more power would be required to propel the ship. To avoid this I provide the said cross tubes with a number of little brackets a^{12} shown clearly in Figure 16. The said brackets clip the transverse tubes at one end, and at their other ends are formed with small eyes a^{13} through which wires a^{14} are tightly stretched. The wires are threaded in a longitudinal direction and they serve as the frame to which the silk covering a^{15} is fixed. It is clear that with such an arrangement the silk while being free to bag between the wires, that is to say in longitudinal grooves, it cannot bag or bulge in the other or transverse direction. In other words the only bulging or bagging that is permissible is that in a longitudinal direction, and such bulging does not interfere with the lifting power of the kite. The air is thus able to act uniformly all over the surface of the silk.

In some cases instead of providing one large aeroplane as above described I divide the aeroplane into two or more smaller ones arranged in line but at different elevations. In such cases I prefer that the rear aeroplane shall be the highest and the forward aeroplane the lowest.

My improved air-ship is provided with two screw propellers driven by twin engines. I may use as the working fluid steam, or the vapour of gasoline, or any other suitable easily volatilized liquid. I prefer to employ in the generator a liquid which boils more easily than water such for instance as ether or gasoline. The following advantages arise from the use of such liquids; the total amount of heat required for evaporating a given quantity of the liquid is less than with water; the temperature required for producing a certain pressure is also less and consequently the tubes of the generator being at a lower temperature may be made thinner; the total amount of heat carried over with the exhaust is less, therefore not so large a quantity of heat has to be taken up by the condenser; the generator and all the passage ways may be made of steel with no tendency to corrode in the interior; and the joints may be united with easily melted solder. Gasoline and similar liquids have moreover very little tendency to prime and the liquid can be separated from the vapour with greater facility than is the case with water.

The boiler is constructed with an outer cylindrical thin metal casing g Figure 17 having a conical hood g^1 and a chimney g^2. In the centre of the casing is a partly cylindrical and partly conical chamber h which communicates by a vertical central pipe h^1 with four radial branch pipes h^2 situated in the lower portion of the casing.

The said branch pipes h^2 connect with a ring shaped or annular pipe h^3, from which branch a very large number of small tubes h^4 the upper ends of which are connected with the central chamber h. The tubes h^4 are bent or curved somewhat as shown within the lower part of the casing thereby increasing very largely the heating surface. Where the tubes cross each other they may be tied together with asbestos cord. I have shown four series of such tubes branching at different angles from the pipe h^3, the alternate tubes in each series being connected with the chamber h at one level, and the intermediate tubes of the same series at a slightly higher level there being eight tiers of tubes in all at the upper end. In this way I provide room for making the joints both with the pipe h^3 and chamber h. The mode of connecting the tubes is clearly shown on a greatly enlarged scale in Figure 19. h^5 is a nipple which is adapted to be screwed into the pipe h^3 or chamber h. The said nipple is coned at h^6 and on this coned end the tube h^4 is forced and then secured thereon by a nut h^7 which screws on the nipple and has a coned end h^8 adapted to bear against and hold the expanded end of the tube. This form of union coupling is very advantageous as there is no necessity for a flange to be formed on the ends of the tubes, and the said tubes are not required to be treated in any way which would draw their temper. Hard drawn unsoftened copper tubes may be used. In some cases I use nickel tubes which may be made very light and strong, and which I find to be of great strength while hot. Within the chamber h is another similar but somewhat smaller chamber i which is supported by an outer flange i^1 formed at its upper end said flange being adapted to rest upon and be fixed to an inner flange h^9 formed at the upper end of the chamber h. An annular space is thus formed between the two chambers. The inner chamber i has moreover a short depending pipe i^2 at its lower end which projects into the vertical pipe h^1. The chamber i is pierced with a number of slits or openings i^3 formed by punching tongues of metal i^4 inwards as indicated in the section Figure 18. i^5 is a conical cover for the chamber i. In this cover is fixed a central vertical pipe j that projects downward some distance into the chamber i and upward into the upper or conical part of the external casing. The said pipe is divided into four compartments by three transverse partitions j^1 j^2 j^3 and it is provided with a large number of perforations j^4 near its lower extremity for the escape of the steam or vapour formed in the boiler. The feed water or other liquid to be evaporated enters the upper chamber j^5 of the pipe j through a pipe k and thence passes through a heater which consists of a larger number of small tubes k^1 coiled in the upper part of the boiler casing. The said tubes communicate at one end with the said upper chamber j^5 of the pipe j and at the other end with a ring shaped pipe k^2 from whence branch a number of radial pipes k^3 which lead to the second chamber j^6 of the pipe j. From this chamber the now highly heated liquid passes down a small central tube k^4 which is fixed at its upper end in the lower partition wall j^2 of the said chamber j^6 and terminates in a nozzle at its lower end near the lower or conical part of the chamber i. I prefer that the feed liquid shall be discharged from the end of the tube k^4 under a pressure considerably higher than that in the boiler so as to escape with great velocity. By this means any surrounding liquid in the chamber i is carried by induction into the pipe h^1 and a strong forced circulation is the result. The greater portion of the liquid is evaporated while passing through the small tubes h^4 and the vapour thus formed, together with any unvaporised liquid, enters the annular cavity between the two chambers h, i and then passes into the inner chamber through the slits i^3. Owing to the peculiar formation of the said slits i and tongue i^4 the liquid and vapour passing through the slits is given a rotary or vortex motion which has the effect of separating, by centrifugal action, the liquid from the vapour, the liquid owing to its greater weight keeping to the outside of the chamber and being eventually sucked down by the fresh incoming feed liquid and caused to circulate again through the tubular system, while the vapour passes to the inside of the chamber and is drawn off in a fairly dry condition through the perforations j^4 in the central pipe j. From the lower chamber j^7 of the pipe j the vapour passes out through a number of radial pipes l which connect the said chamber with a ring shaped or annular pipe l^1. The latter pipe is connected by a large number of small coiled tubes l^2 with the fourth chamber j^8 of the pipe j. In passing through this superheater the vapour is thoroughly dried and by the time it enters the collecting chamber j^8 it is devoid of the last traces of liquid. m is the pipe which conveys the vapour from the collecting chamber j^8 to the engine.

I prefer that the nozzle in the lower end of the feed tube k^4, shown very clearly in Figures 17^A and 17^B, shall have a variable opening for which purpose I provide the said nozzle with a cone k^5 which fits in the mouth of the pipe k and which is acted upon by a spiral spring k^6 so arranged that it tends to close the orifice by forcing the cone therein. The said cone is provided with lugs or ears k^7 that fit within the tube k^4 and it is screwed or otherwise fixed to a spindle k^8 which is secured to a cross-bar k^9 adapted to slide within the tube k^4. k^{10} is another cross bar which is fixed in the tube k^4. The spring k^6 is compressed between the two cross bars k^9 k^{10} and thereby exerts a force that tends to draw inwards the cone k^5 so as to close the mouth of the feed-tube. The pressure of the feed liquid tends to force the cone outward to open the orifice but before it can do so the pressure must be sufficiently high to overcome the internal pressure of the vapour in the boiler and the pressure of the spring k^6. In this manner, no matter whether a large or a small quantity of liquid is passing, it will escape between the cone and the nozzle with great force. It is this force which causes the rapid forced circulation of the liquid through the boiler and enables me to use much smaller and lighter tubes than would be necessary were the circulation due to gravity alone.

The arrangement of feed heater hereinabove described is very advantageous inasmuch as the heated products of combustion after having given up as much heat as they can do to the heated tubes below, impinge upon the tubes containing the cold feed liquid in the upper portion of the casing. The maximum amount of heat is thus got out of the gases, and the boiler is therefore worked economically.

My said improved boiler is adapted for burning liquid or gaseous fuel. n is the burner which consists of a large central tube n^1 from which project on each side thereof a number of small tubes n^2. The said tubes n^2 are perforated at the sides as indicated in Figure 22 so that the issuing streams of gas will impinge against each other. n^3 n^3 are parts of a deflector which is placed above the tubes n^2 and is shaped as clearly shown in the section Figure 22. The slits n^4 between the parts n^3 n^3 are situated above the space between the tubes n^2. By this arrangement, the flame passing up between the curved sides n^5 of the deflector and through the slits n^4 causes a sharp draught of air which combines with the combustible gas and produces a very intense jet above the deflector. The parts n^3 of the deflector are joined together at their outer ends by a ring n^6 and also about mid length by metal strips n^7 riveted thereto as shown in Figure 23. Immediately below this part of the deflector the holes in the burner tubes n^2 are drilled at the top as shown in Figure 23. The object of this construction is to communicate the flame from one burner tube to another, so that if one burner is lighted all the rest become lighted therefrom. The gas or vapour is conveyed to the central tube n^1 through an inner perforated tube n^8 at the end of which is a regulator o for regulating the admission of vapour as required. The regulator is shown in detail on an enlarged scale in Figures 24 to 26. o^1 is the feed tube for the volatilized petroleum, the said pipe being connected to the end of the tube n^8. o^2 is a nozzle projecting axially into the tube n^8. o^3 is a branch pipe for the admission of air, the said pipe being fitted with a wing valve o^4 to regulate the quantity of air admitted. In the end of the nozzle o^2 is fitted a conical plug o^5 which is connected by links o^6 o^6 with a lever o^7. To the lower end of the said lever is pivoted at o^8 one end of a rod o^9 which has at its other end a disc o^{10} that is free to slide in a casing o^{11}. The said casing is pivoted at o^{12} to a fixed bracket o^{13}. Between the disc o^{10} and the cover o^{14} of the casing is a spring o^{15}. o^{16} o^{17} are two cylinders secured to a bracket o^{18} fixed to the end of the tube n^8, are fitted respectively with pistons o^{19} o^{20} the rods of which are coupled to the lever o^7. The upper end of the lever o^7 is moreover fixed by means of a link o^{21} which is secured at one end to the tube o^1 and at the other end by a bolt connection o^{22} to the said lever o^7. The cylinders are slotted at o^{23} to allow the lever o^7 to move backwards and forwards therein. One of the cylinders as for instance o^{16} is in communication with the boiler by a tube o^{24} so that a pressure is maintained in the said cylinder approximately equal to that in the boiler. The other cylinder is connected by a pipe o^{25} with a small annular chamber p provided in the boiler to surround the lower portion of the chamber h. The said chamber p is filled with water. Should there occur a failure of the pump or pumps so that the liquid is not supplied to the boiler in sufficient quantities, the water in the annular chamber p becomes over heated and expands, thus forcing back the piston o^{20} against the resistance of the spring o^{15} and partially or wholly closing the valve or plug o^5 thereby reducing or shutting off the supply of fuel to the burners. When the normal condition of things is restored the plug is moved back and allows the full supply of fuel to pass. During the movement of the pistons o^{19} o^{20} the lever o^7 turns about the connection o^{22} as a pivot. The same action occurs if the pressure of the steam or vapour becomes too high. In this case the piston o^{19} is forced back and the supply of fuel thereby reduced. The piston rod of the cylinder o^{16} is extended and passes through the cylinder end. It is screw-threaded and provided with a nut o^{26} which has a crank handle o^{27} whereby the said nut can be screwed against the cylinder end and the lever o^7 drawn back thus shutting down the plug o^5. The lever o^7 can be very soon released from the link o^{21} when required by loosening the thumb nut on the bolt o^{22}. o^{28} is a spring handle fixed to the spindle of the valve o^4 whereby the said valve can be adjusted to regulate the admission of air. o^{29} is a notched bar for retaining the lever o^{28} in any position to which it may be set. I prefer that the volatilized petroleum shall issue from the nozzle o^2 with a pressure of about 20 lbs., though I may vary this pressure materially. Where I use gasoline, naphtha or other light petroleum as the working fluid in the boiler I prefer to utilize a portion of the vaporized hydrocarbon for burning under the boiler to effect the evaporation. In this case the feed tube o^1 draws its supply from the pipe leading to the engine. I make the burner tubes and the deflectors of nickel or preferably an alloy of nickel and iron (the iron prevents the nickel from cracking) as I find that this metal or alloy is practically the only one except platinum which will answer the purpose. Platinum is too heavy and expensive.

My improved boiler is very strong, very light, and very efficient.

The engines which I prefer to employ are of the vertical inverted single acting type. They are clearly shown in the sectional view Figure 27. I provide two cylinders q q arranged side by side and connected at the top by a plate q^1 to which vertical pillars q^2 that carry the crank shaft q^3 are bolted. The crank shaft and cylinders are enclosed in a casing r which is rendered necessary or advisable because the vapours of gasoline or ether do not carry a large amount of heat and therefore to prevent condensation the cylinders must be well encased. I sometimes burn a certain proportion of the vapour direct from the boiler or a portion of the exhaust vapours in the said casing r to keep the cylinders at a temperature considerably above that of the working fluid. Such a device is shown in the figure; r^1 is a jet supplied with vapour from the exhaust pipe. r^2 is a valve for regulating the flame, and r^3 is a chimney to conduct the hot gases into the casing r. I may heat the cylinders from any other source. The cylinders are provided with a common horizontal valve box s. s^1 is the valve which is of the ordinary cylindrical balanced type such as that above described as applied to the cylinder for controlling the rudders; s^2 s^2 are the admission ports; s^3 s^3 the valve faces. s^4 is the vapour supply pipe which conducts the vapour to the space between the two valve faces. s^5 s^5 are the exhaust outlets, leading into a common exhaust pipe s^6. The valve rod s^7 works through a stuffing box s^8 and is connected by a link s^9 and bell-crank lever s^{10} with the eccentric rod s^{11}. s^{12} is the eccentric. The lever s^{10} is pivoted at s^{13} on a bracket s^{14} fixed to the casing r. t is the pump the construction of which is shown more clearly in Figure 29. It is seen to be of the rotary kind and is constructed on the same principle as a Root's blower. The casing t^1 is made very strong and is preferably made of gun metal or phosphor bronze. The rotary vanes or wheels t^2 t^2 are made of hardened steel, and the teeth are very accurately constructed so as to avoid leakage. In each end of the casing I provide a recess t^3 to enable the liquid which is squeezed out from between the teeth as the said teeth successively engage with each other to escape freely. The advantages of a rotary pump of this kind are very many, for instance the pump will force hot or cold liquid or vapour equally well. It requires no valves, and is efficient at a very high speed. Therefore I am enabled to attach it directly to the crank shaft as is shown in Figure 27 thus saving the weight of mechanism which would otherwise be required to transmit the motion to the pump.

The engines being single acting on piston rods or cross-heads are required, as the connecting rods q^4 can be attached directly to the pistons. Moreover no fine adjustment of the crank pins is required. To make up for the loss of support to the pistons due to the absence of the piston rod I make the pistons q^5 very long. The piston consists of a ring closed at the lower end having connected therewith a transverse tubular piece q^6 to which the connecting rod is pivoted. The construction of the pivot is very simple. The tubular piece q^6 is divided at the centre to allow the end of the connecting rod to pass between the two portions of the tube. A pin q^7 is passed through the tubes and through the end of the connecting rod to secure the two together. This pin does not receive any special fastening as it cannot come out when the piston is placed in the cylinder. The engines are provided with reversing gear which comprises an eccentric that can be moved across the crank shaft from full speed ahead to full speed astern or that can be set to any intermediate position so as to give any desired degree of angular advance thereby cutting off the vapours at any desired part of the stroke. The eccentric may be a very small one. s^{15} is a rectangular guide formed on the end of the crank shaft to carry the eccentric and on which the eccentric can slide backward and forward. For moving the eccentric as desired I provide it with an opening s^{16} in the side of which are formed a number of skew teeth s^{17} adapted to engage with corresponding skew teeth formed in a rack u. The said rack is situated in the axle of the crank shaft and is coupled by a ball and socket joint u^1 to a reversing lever u^2 which is pivoted at its upper end to a bracket u^3 and is provided at its lower end with a handle u^4. Owing to the ball and socket connection u^1 the rack u is free to rotate with the crank shaft while being connected with the lever u^2. u^5 is a notched curved bar, fixed to the casing, and u^6 is a spring actuated catch carried by the lever u^2 and adapted to engage with any one of the notches in the bar u^3 and to hold the lever stationary when so engaged. By raising the spring catch and then moving the lever, the rack bar u is moved in or out of the eccentric and the said eccentric is by the skew teeth on the said rack caused to slide one way or the other on the guide s^{15}. The angular advance of the eccentric and the cut-off can be thus altered as desired or by continuing the movement of the rack u the engine can be reversed.

The exhaust vapours on leaving the engine are conveyed as before described through the hollow rods of the framework of the machine to the condenser F. After condensation the liquid falls into the lower part of the framework, and is thence pumped again into the boiler. The condenser consists of a number of very small tubes which present a large surface to the atmosphere and thereby operate very effectually to condense the vapours.

In using a liquid such as gasoline in a boiler, it is found that each time the liquid is evaporated a small proportion of vapour is produced which is not easily condensable. This is owing to gasoline not being a homogeneous substance. I therefore get rid of these non-condensable vapours by burning them in the boiler furnace. In some cases I supply the burners altogether with vapour taken from the exhaust. In other cases I employ for the larger portion of the fire the vapours of some heavier petroleum which is cheaper than gasoline. In such cases I prefer to use a certain amount of the heat which escapes through the series of tubes for generating vapours from the said heavier petroleum.

I sometimes use a compound engine such as shown in Figure 30 instead of the simple engine above described. q^8 q^9 are the high and low pressure cylinders respectively and q^{10} is the exhaust pipe of the small cylinder. q^{11} is a bye-pass leading from the main steam pipe q^{12} into the exhaust pipe q^{10}. q^{13} is a double cone valve intended for closing the end of the said bye-pass. The said cone is provided with guides q^{14} which are a sliding fit in the pipe q^{11} and it is attached to a spindle q^{15} which passes out through a stuffing box q^{16}. q^{17} is a spring for forcing the cone against its seat. The compression of the spring is regulated by an adjusting nut q^{18} by which the cone can be set to open at any desired pressure. By this device I am enabled to allow when necessary, as for instance when starting the engine, more steam or vapour to enter the low pressure cylinder than is discharged from the high pressure cylinder. My improved device differs from the ordinary relief valve devices heretofore used for admitting extra steam to the large cylinder inasmuch as in my arrangement the force exerted by the vapour in passing from a high to a low pressure is utilized in pushing the steam or vapour along in the pipe to the low pressure cylinder. That is to say, this pipe is made into an injector, the suction being the exhaust of the high pressure cylinder and the discharge the inlet to the low pressure cylinder, while the inducing jet is the steam or vapour that passes direct from the boiler to the low pressure cylinder. This injector action reduces the back pressure on the high pressure piston and enables me to have a higher working pressure in the large cylinder than the back pressure in the small cylinder, consequently more work is done by the engine.

As before stated I provide two screw propellers E placed side by side and a pair of engines such as above described for driving each propeller. I may arrange to steer the air-ship by driving one screw faster than the other. This is accomplished by placing a butterfly valve in the main supply pipe so that it may be turned in either direction and caused to close or partially close the supply pipe to either engine as desired.

I prefer to make the screw-propellers solid. For this purpose I make them of narrow strips of wood z Figures 31 and 32 which are superposed so that they overlap one another after the manner of the ribs of a ladies fan. The said strips are glued or cemented together somewhat as are the strips used in building up a wooden pattern for moulding the propellers of steam ships. The said strips are moreover held firmly together by metal clamps or flanges or in any other convenient manner. After the said strips are united as above described, the blades thus formed are worked down very thin, and are prevented from splitting by gluing or cementing to their surface cloth, linen parchment or similar substance. The whole is then painted or otherwise treated to preserve the wood and other substance. I provide the blades with stiffening pieces z^2 extending in a circumferential direction, and I sometimes stay the ends of the blades by wires or cords so as to overcome or resist the thrust.

I provide for holding down the machine until it has acquired sufficient horizontal velocity to cause it to rise in the air as follows, that is to say v v are flanged wheels adapted to run on a railway track. The bearings v^1 for the wheel axles are carried by flat springs v^2 which are secured at their ends in a wooden frame v^3 attached to the frame work of the ship. The flat spring bearing pieces v^2 are supported or reinforced by spiral springs v^4. I provide four such wheels, one at each corner of the car. I also provide a double parallel set of rails, one below the wheels to support the weight, and another above the wheels to prevent the machine rising. By this arrangement the machine is held down and caused to run on the rails until by the time the end of the track is reached the machine has acquired sufficient velocity to cause it to rise in the air. For the purpose of adjusting the machine before flight is attempted I preferably employ a circular track of rails on which the car runs. I also use a set of very heavy wheels nearly as heavy as the whole machine. These wheels are removed and replaced by light wheels when flight is to be made. In some cases the upper set of rails may be dispensed with.

I provide in combination with each wheel r a dynagraph for the purpose of recording or indicating the upward lift of the aeroplane when adjusting the machine on the railway track. Each dynagraph is arranged as follows: w is an indicator cylinder carried in bearings w^1 in a frame w^2 and adapted to be driven by worm gear w^3 and belts w^4 w^4 from a small pulley w^* fixed on the wheel r. w^5 is an arm adapted to carry a pencil and attached to a rod w^6 which can slide vertically in bearings w^7. The said rod w^6 is connected by a link w^8 with one end of a lever w^9 that is pivoted at w^{10} to the frame-work. The said lever w^9 is connected at its other end by a link w^{11} with the wheel axle or bearing. When the machine is driven forward while the wheels r are retained between the rails, the lifting force on the aeroplane causes a lifting of the frame with respect to the wheels. The rod w^6 is thereby raised and the pencil carried by the arm w^5 traces a line on a paper sheet placed around the cylinder w the height of which line from a base line is proportional to the lifting force. By this means the lift is registered and the occupant of the car can thus tell whether the machine when released from the rails will rise as it ought to do.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that I claim the following improvements in or relating to aeronautic apparatus or air-ships, *viz.*,—

1. The combination of a fixed inclined aeroplane or kite which sustains the weight of the machine, and fore and aft rudders so tied that one cannot turn without the other, substantially as, and for the purpose, specified.
2. An aeronautic machine or air-ship provided with and controllable by an apparatus such as that herein termed a gyrostat, for the purposes specified.
3. The combination of one or more rudders for guiding the ship, and a gyrostat for automatically controlling the position of the said rudder or rudders, for the purpose specified.
4. The combination, with a fluid pressure motor for working the rudders, of a gyrostat for controlling the distributing valve of the said motor, with or without means such as herein described for automatically restoring the said valve to its mean position when the rudders are adjusted, for the purpose specified.
5. The means for reversing the distributing valve of the rudder-operating motor, substantially as, and for the purpose, specified.
6. A gyrostat constructed substantially as described with reference to Figure 6 of the drawings, for the purpose specified.
7. The combination, with the gyrostat, of the indicating device constructed and arranged substantially as described with reference to Figures 13 and 14 of the drawings, for the purpose specified.
8. The device for adjusting the point of suspension of the gyrostat in order to regulate the angle of inclination of the air-ship, with or without the indicating device to show the angle to which the air-ship is set to fly, substantially as described.
9. The apparatus for controlling the rudders, constructed substantially as described with reference to Figures 5 to 14 of the drawings, and operating as specified.
10. The combination, with the framework of the aeroplane or kite, of short brackets a^{12} mounted on the transverse tubes of the framework and carrying tightly stretched wires for supporting the covering of the kite, substantially as described, for the purpose specified.
11. The method of causing the circulation of the liquid in the boiler by the action of the entering feed-liquid, as hereinbefore described.

12. A boiler having a central chamber such as h for receiving the feed liquid, circulating pipes h^1, h^2, h^3, and a large number of small generating tubes h^4 enclosed in a shell or casing, substantially as, and for the purpose, described.

13. The feed heater, constructed and arranged in the hood of the boiler casing, substantially as described, in combination with the central chamber h and distributing pipes, and generating tubes of the boiler, for the purpose specified.

14. The spring-controlled cone-nozzle k^5, constructed and arranged substantially as described with reference to Figures 17, 17^A and 17^B, for the purpose specified.

15. In the generator, the combination with the central chamber h, of the vertical feed pipe arranged to deliver into the mouth of the cone-shaped lower extremity or of the inner chamber i have openings in its wall; or of the circulating and generating tubes, and the superheater, or of any or all of these features, substantially as, and for the purposes, specified.

16. In a gentrator such as herein described, the mode of connecting the small generating tubes to the circulating pipe and central chamber by a union, without brazing or soldering, substantially as described with reference to Figure 19 of the drawings, for the purpose specified.

17. The combination with the generator herein described of a union constructed as described with reference to Figure 19 for the purpose specified.

18. The combination, with a generator such as herein described, of a burner or furnace consisting of a number of perforated burner tubes in combination with curved deflectors arranged above said tubes, substantially as described with reference to Figures 21, 22 and 23, or otherwise suitably arranged for the purpose specified.

19. In combination with a generator such as herein described the use of burner tubes, and deflectors, made of an alloy of nickel and iron, substantially as described, for the purpose specified.

20. The herein described method of regulating or controlling the supply of liquid fuel to the furnace of a boiler or generator by the vapour pressure and the temperature within the boiler, acting together on the same valve for the purpose specified.

21. The means for shutting down the plug o^5 substantially as described with reference to Figure 24, for the purpose specified.

22. A double acting liquid-fuel-regulator constructed substantially as described with reference to Figures 24, 25 and 26 of the drawings, and operating as specified.

23. A boiler constructed substantially as described with reference to Figure 17, for the purpose specified.

24. An engine adapted for using hydrocarbon vapour as the working fluid and enclosed in a casing which is heated internally by a burner supplied with vapour from the exhaust pipe of the engine, for the purpose specified.

25. Attaching the rotary pump directly to the crank shaft, substantially as described, for the purpose specified.

26. An engine and boiler using gasoline or other hydrocarbon as the working fluid and arranged to burn a portion of the working vapour under the boiler to remove the uncondensable vapour formed after each re-evaporation.

27. In a compound engine, a bye-pass arranged in the high pressure exhaust pipe for the passage of steam or vapour direct from the boiler, the said bye-pass constituting an injector which draws from the exhaust port of the high pressure cylinder and discharges into the inlet of the low pressure cylinder, for the purpose specified.

28. The bye-pass q^{11} in combination with the spring controlled valve q^{13} substantially as described with reference to Figure 30, for the purpose specified.

29. A solid screw-propeller formed of narrow strips of wood cemented together and having cemented to the wood a covering formed of textile fabric, substantially as described.

30. A screw-propeller constructed substantially as described with reference to Figures 31 and 32 of the drawings, for the purpose specified.

31. The framework of the air ship, constructed and arranged substantially as described with reference to Figures 1 to 4 of the drawings for the purpose specified.

32. The aeronautic apparatus or air-ship constructed substantially as herein described.

Dated this 6th day of August 1892.

HASELTINE, LAKE & Co.,
45, Southampton Buildings, London, W.C., Agents for the Applicant.

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[Wt. 15—250/5/1913.]

A.D. 1891. Nov. 6. No. 19,228.
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Fig. 1.

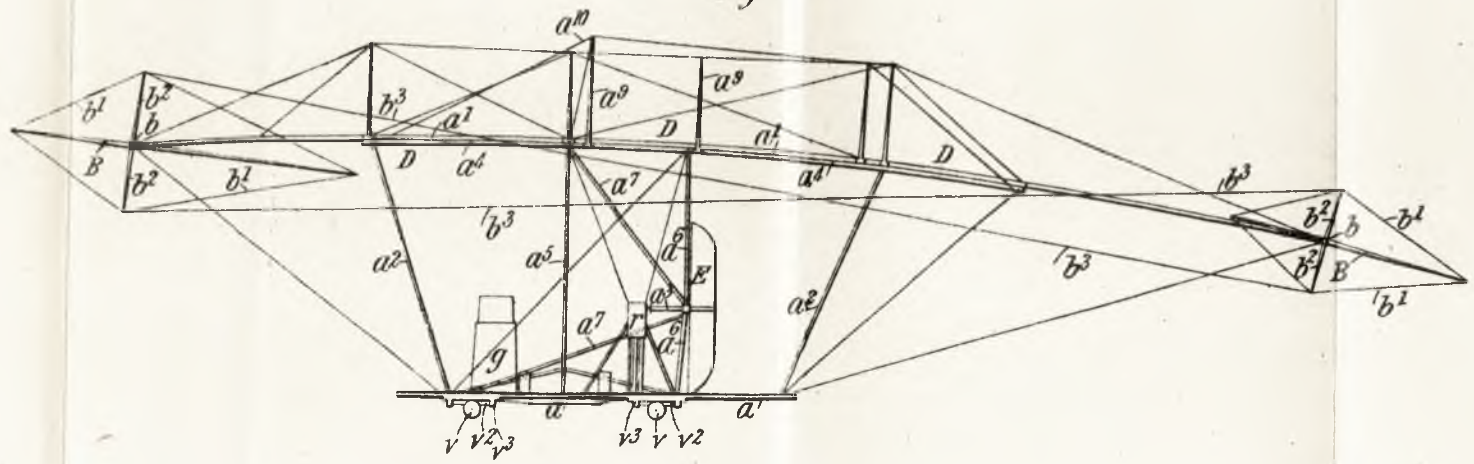
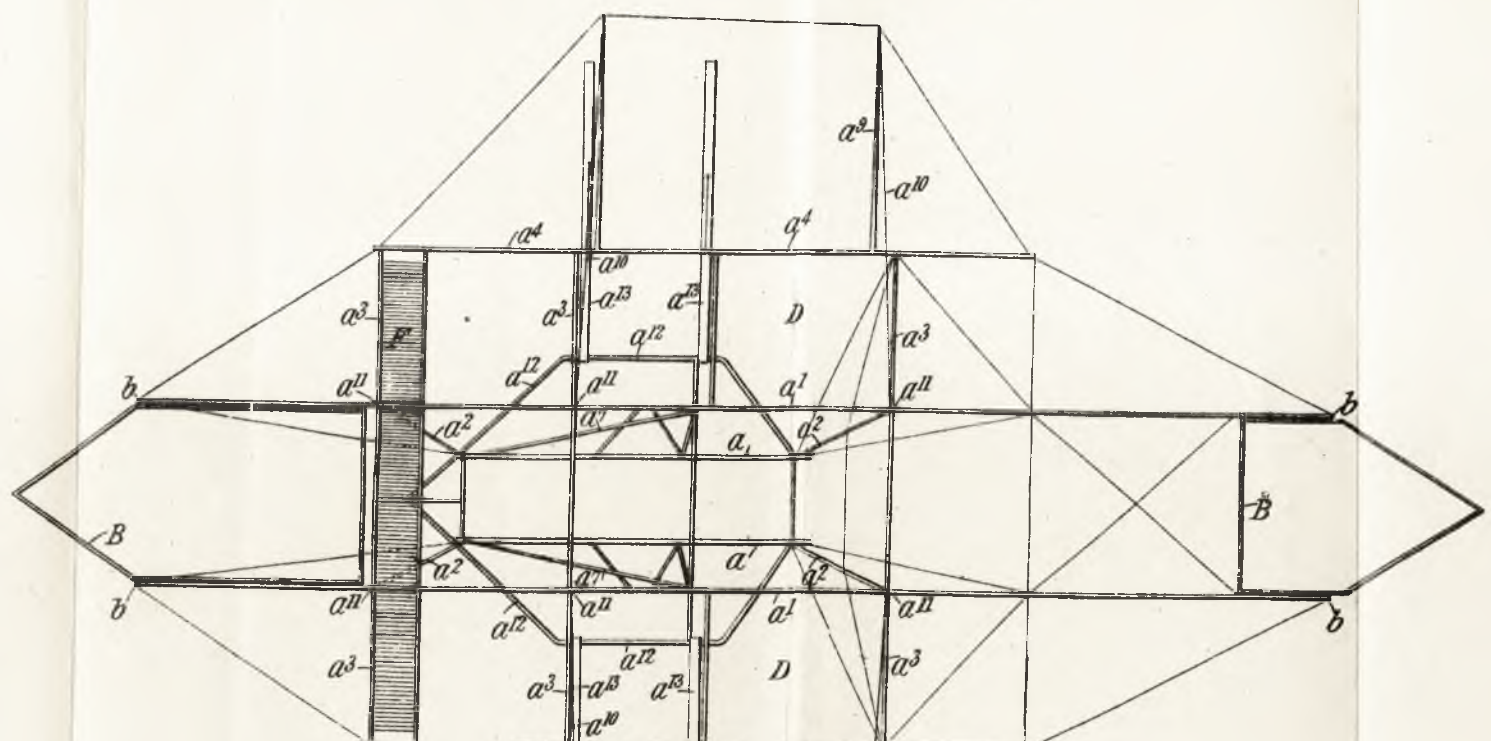


Fig. 2.



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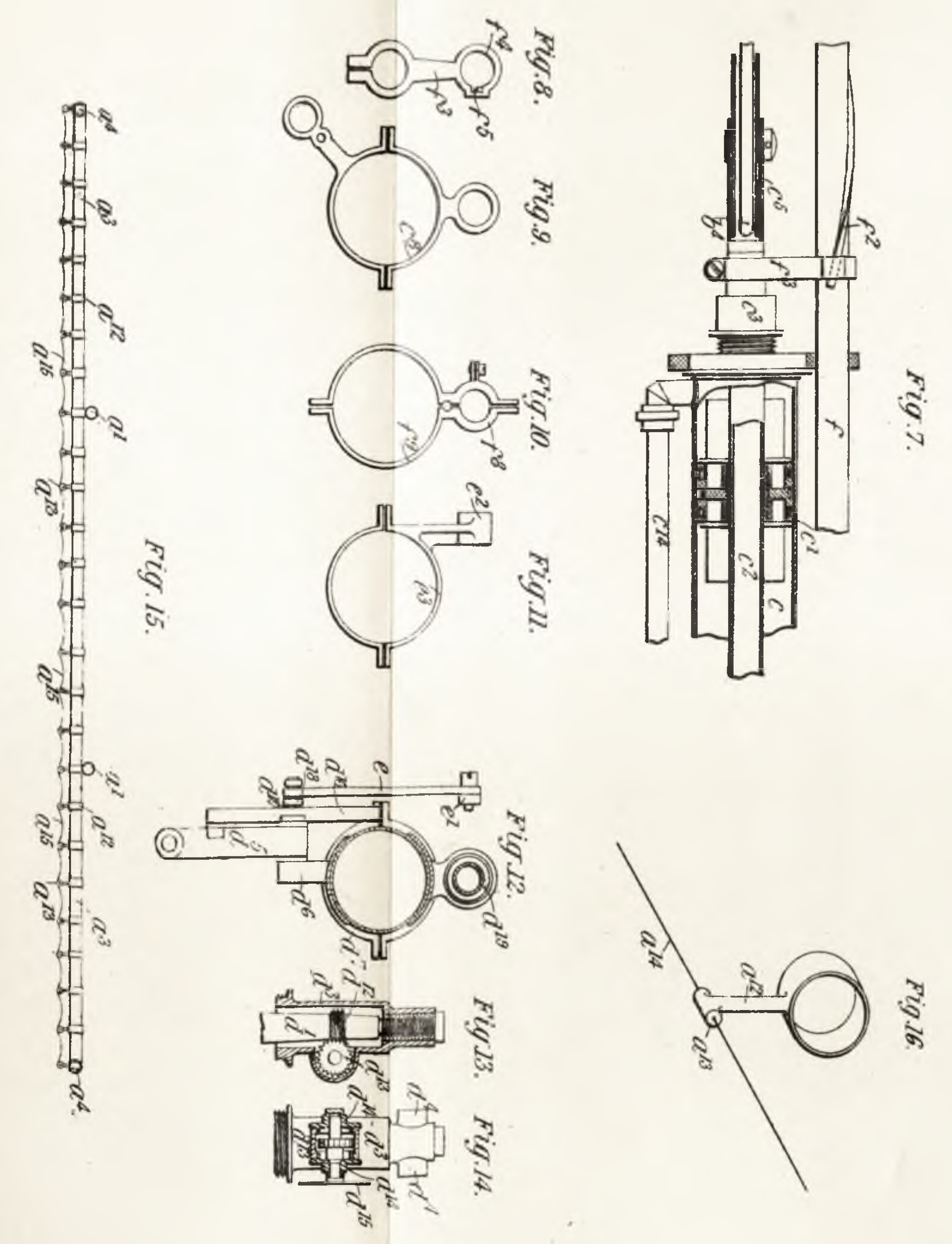

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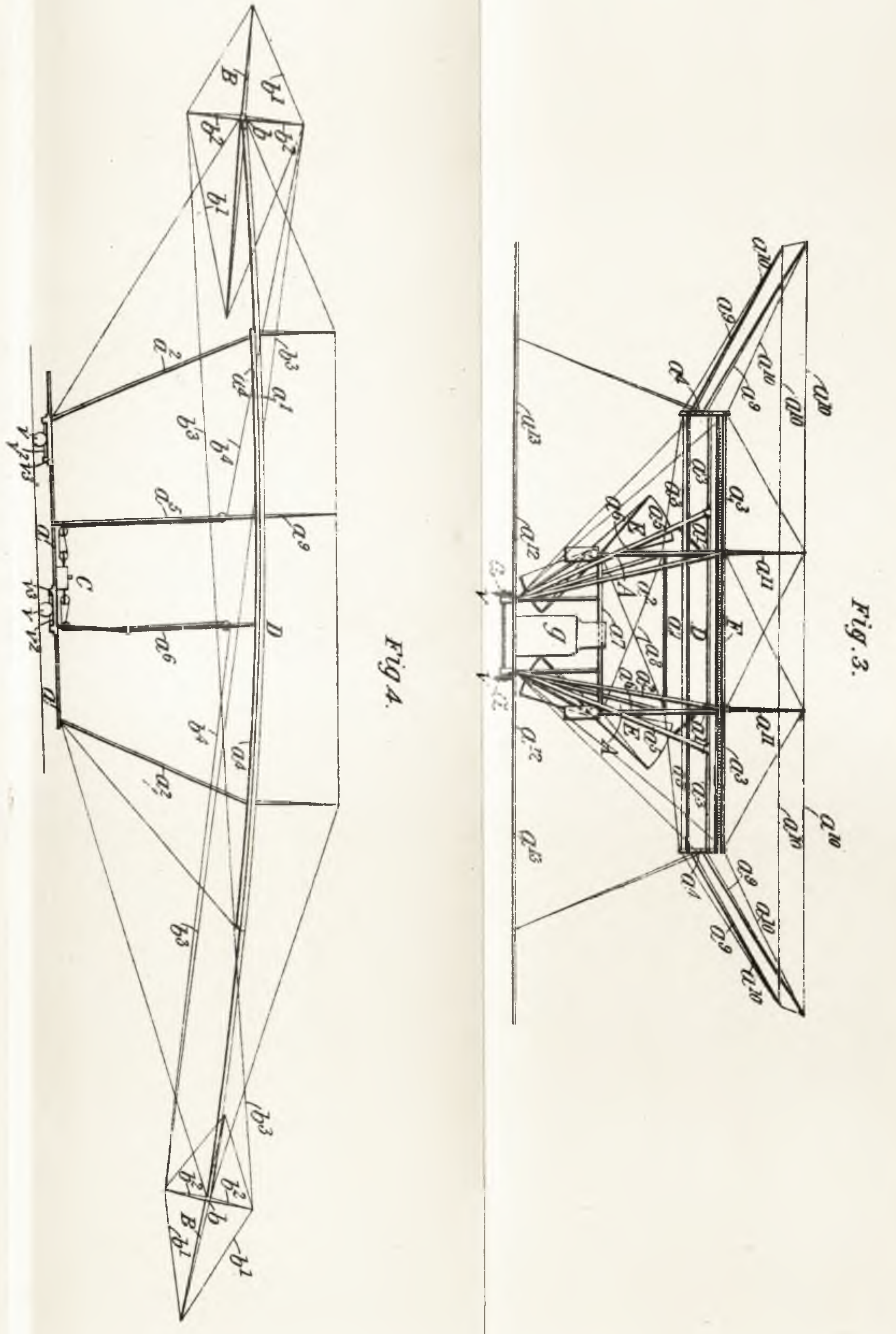

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Fig.5.

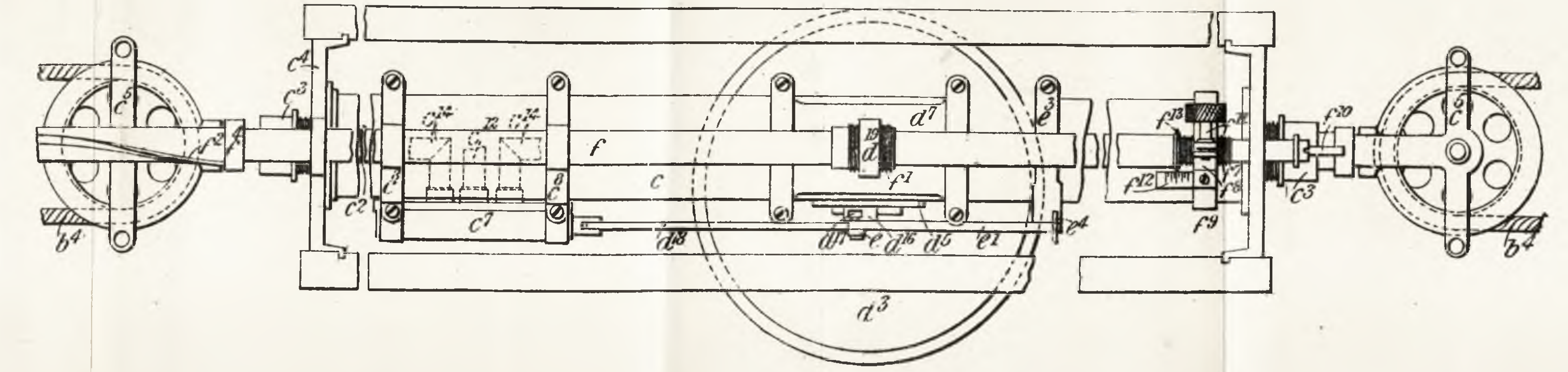
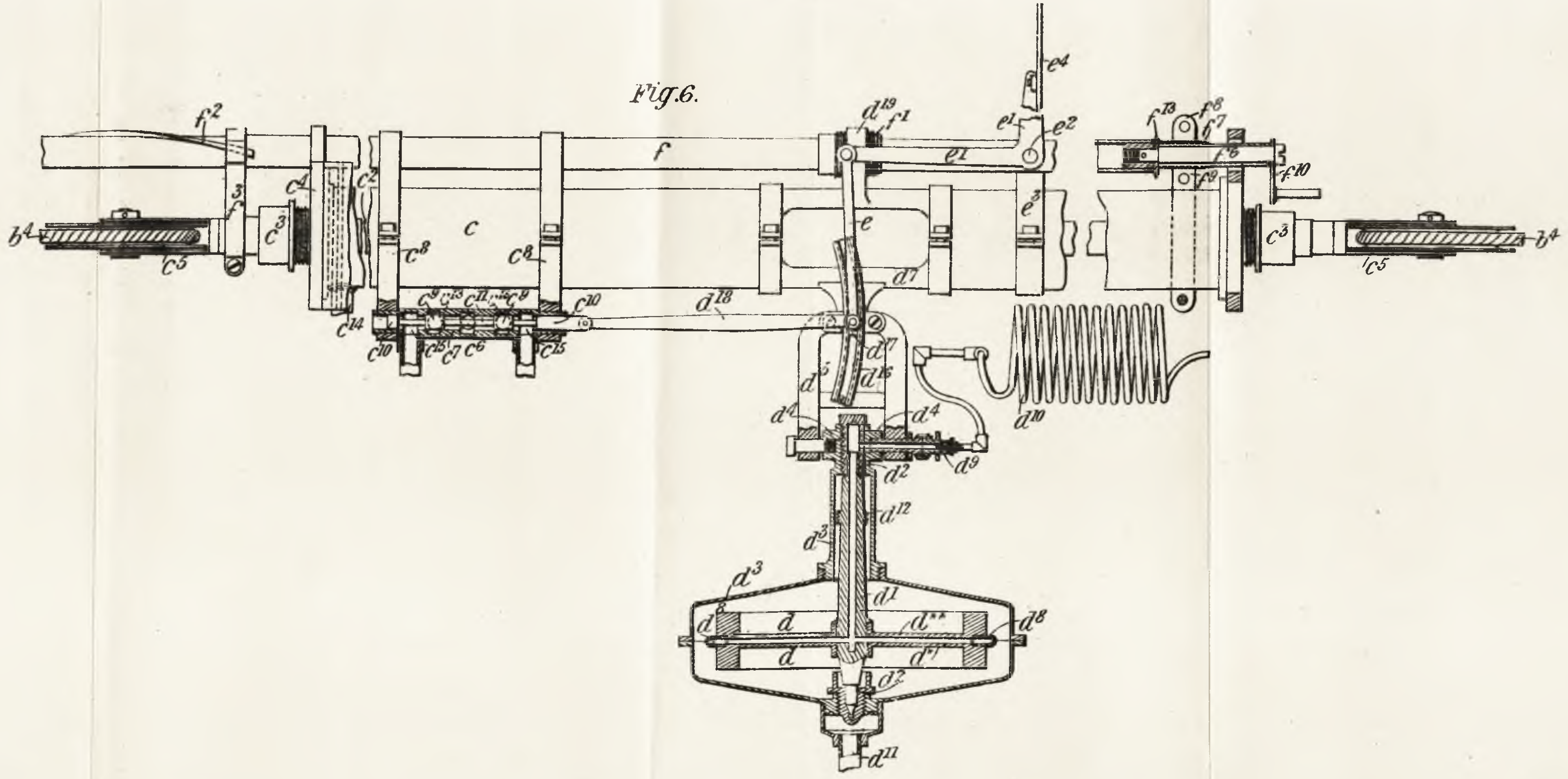


Fig.6.



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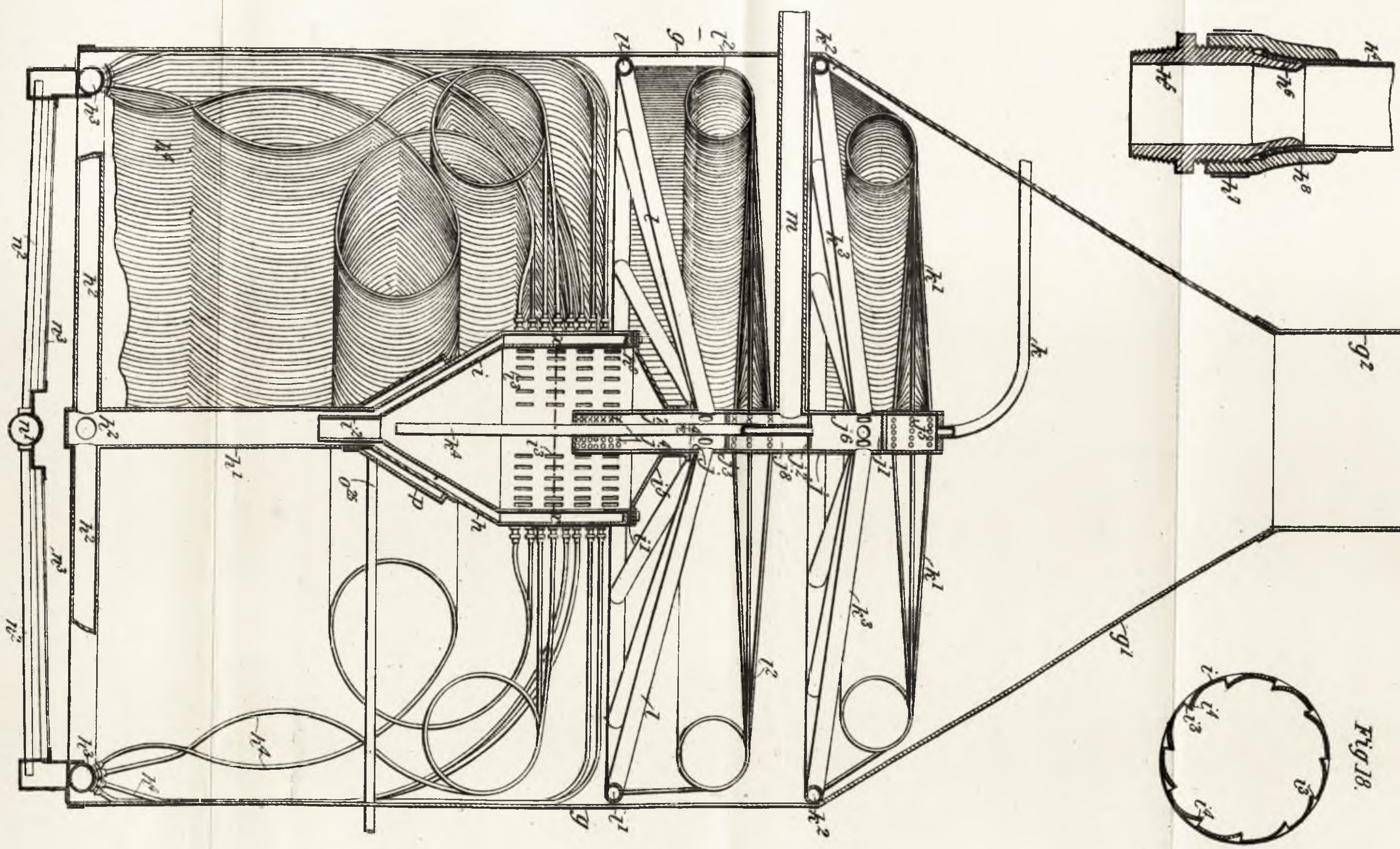

Fig.17. Fig.18. Fig.19.

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SHEET 7.

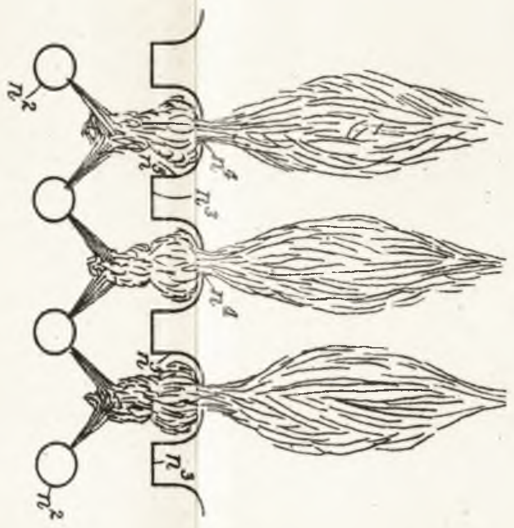


Fig. 22.

Fig. 23.

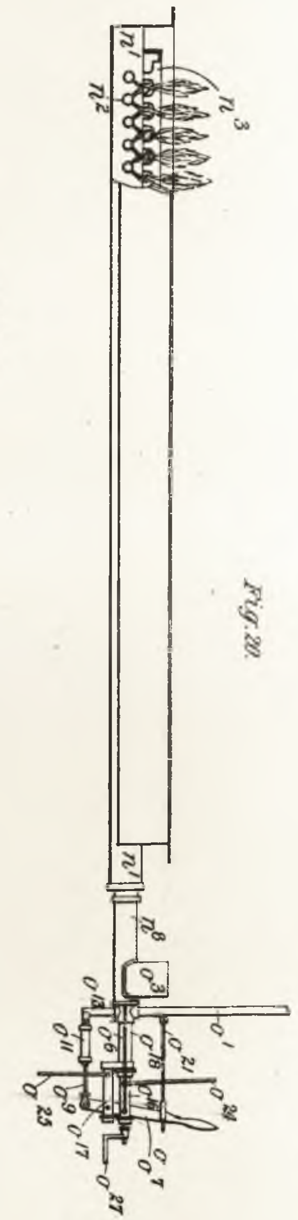
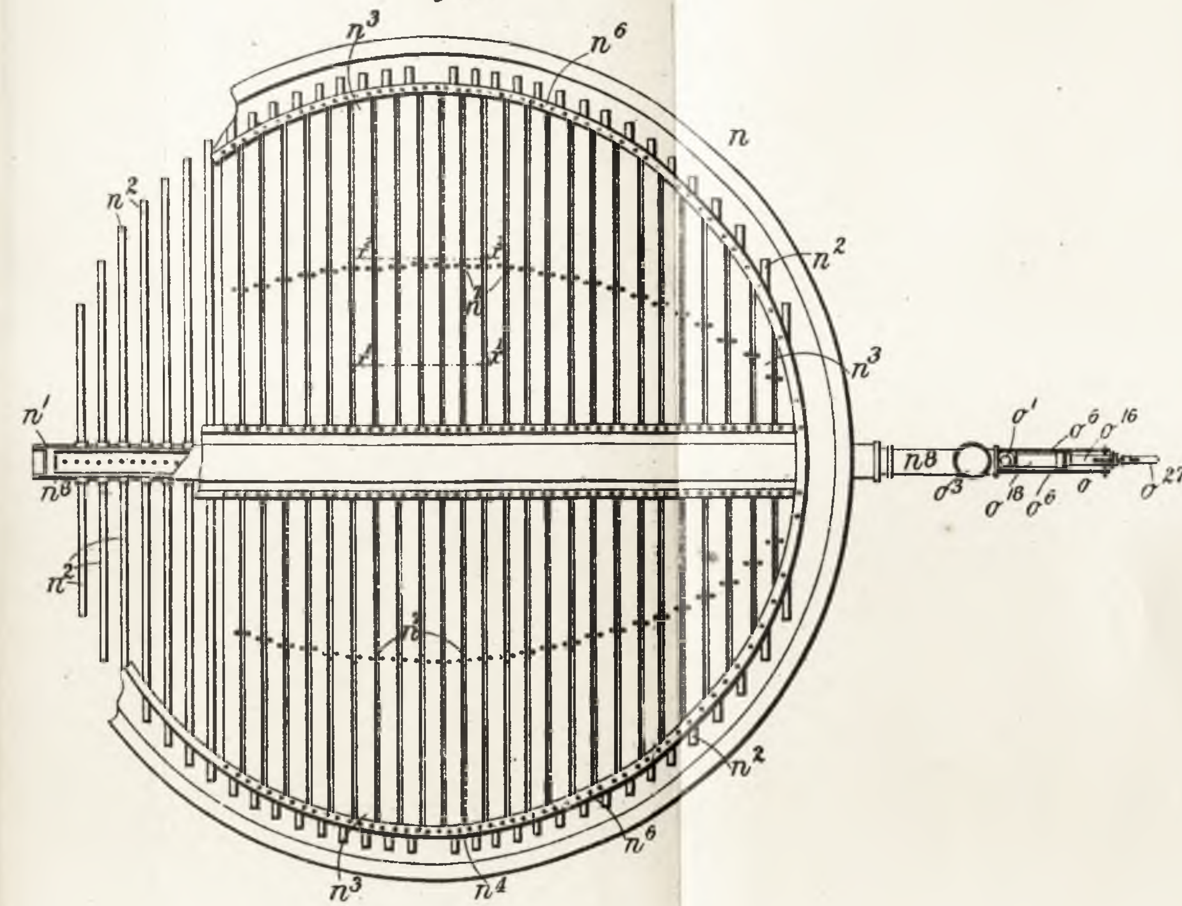


Fig. 20.

Fig. 21.



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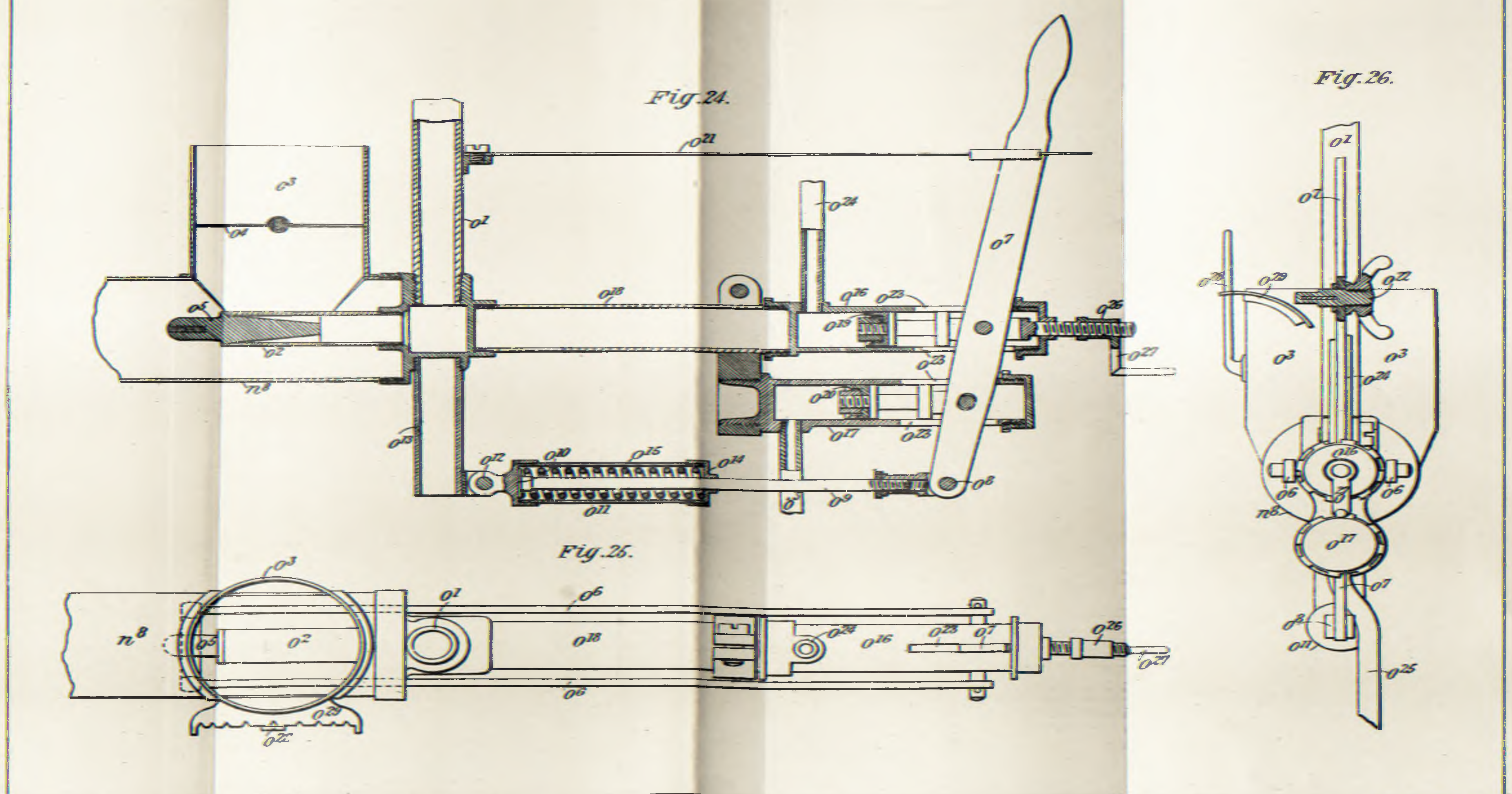

Fig. 24.

Fig. 25.

Fig. 26.

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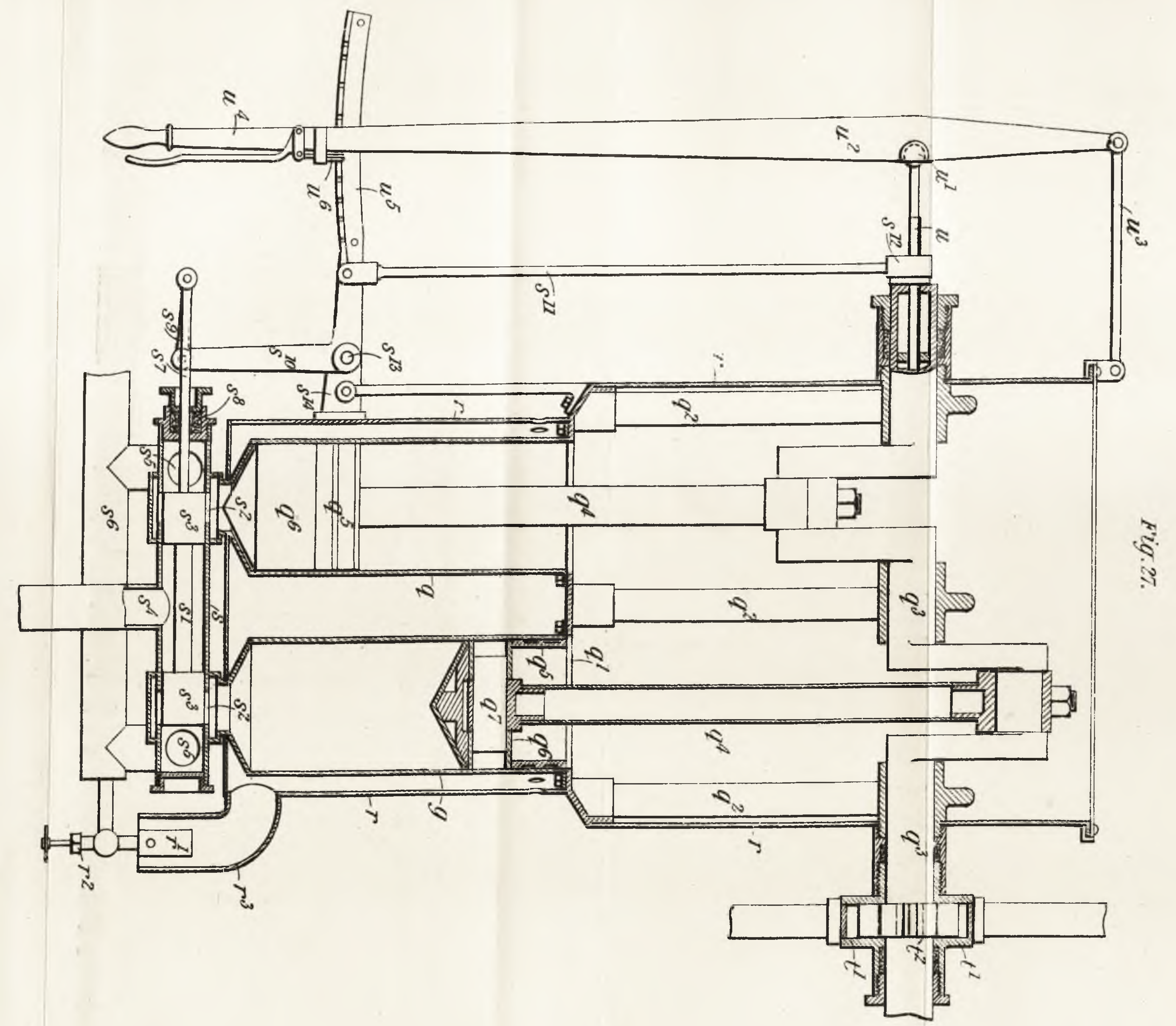

Fig. 27.

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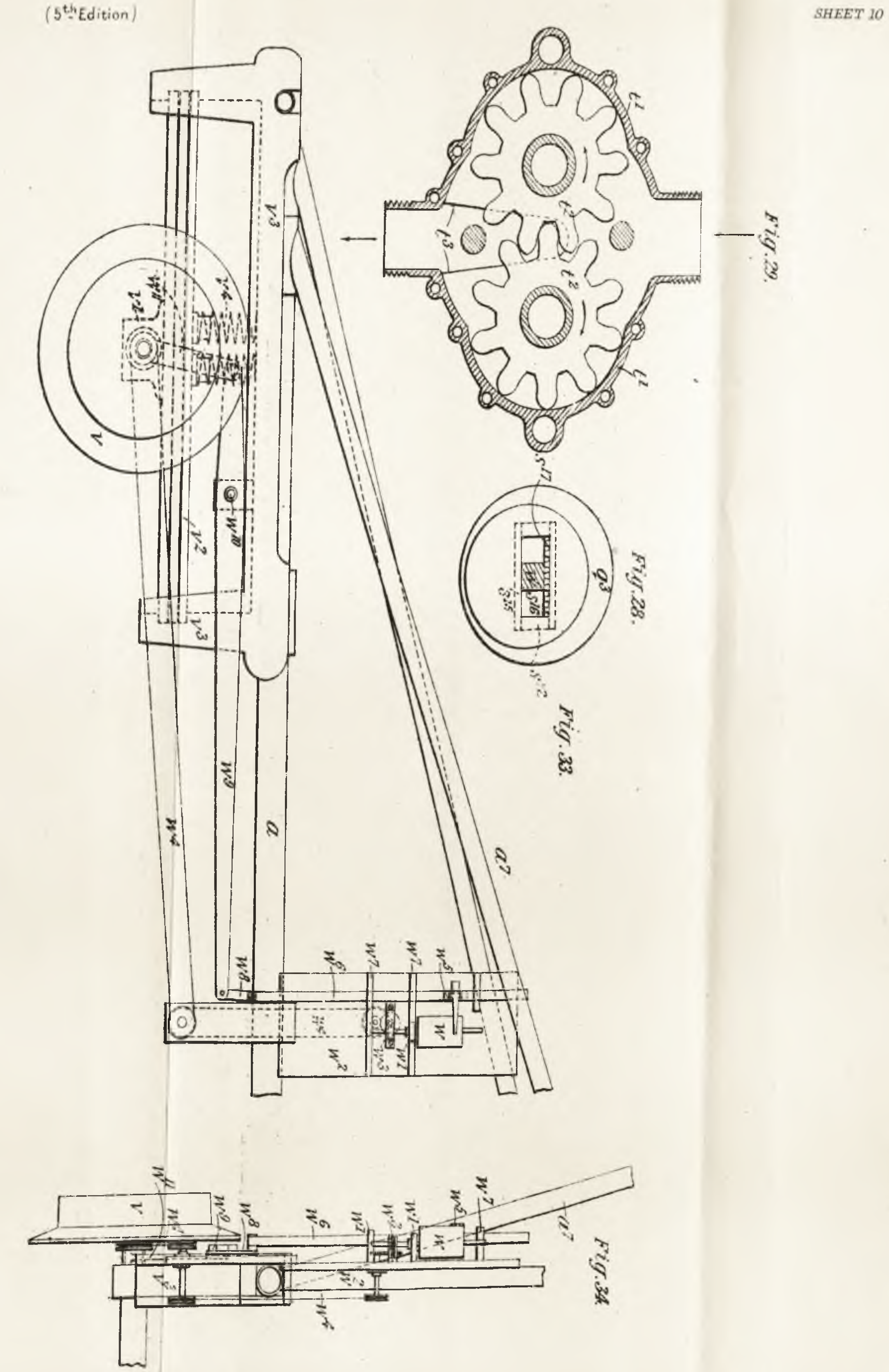

SHEET 11

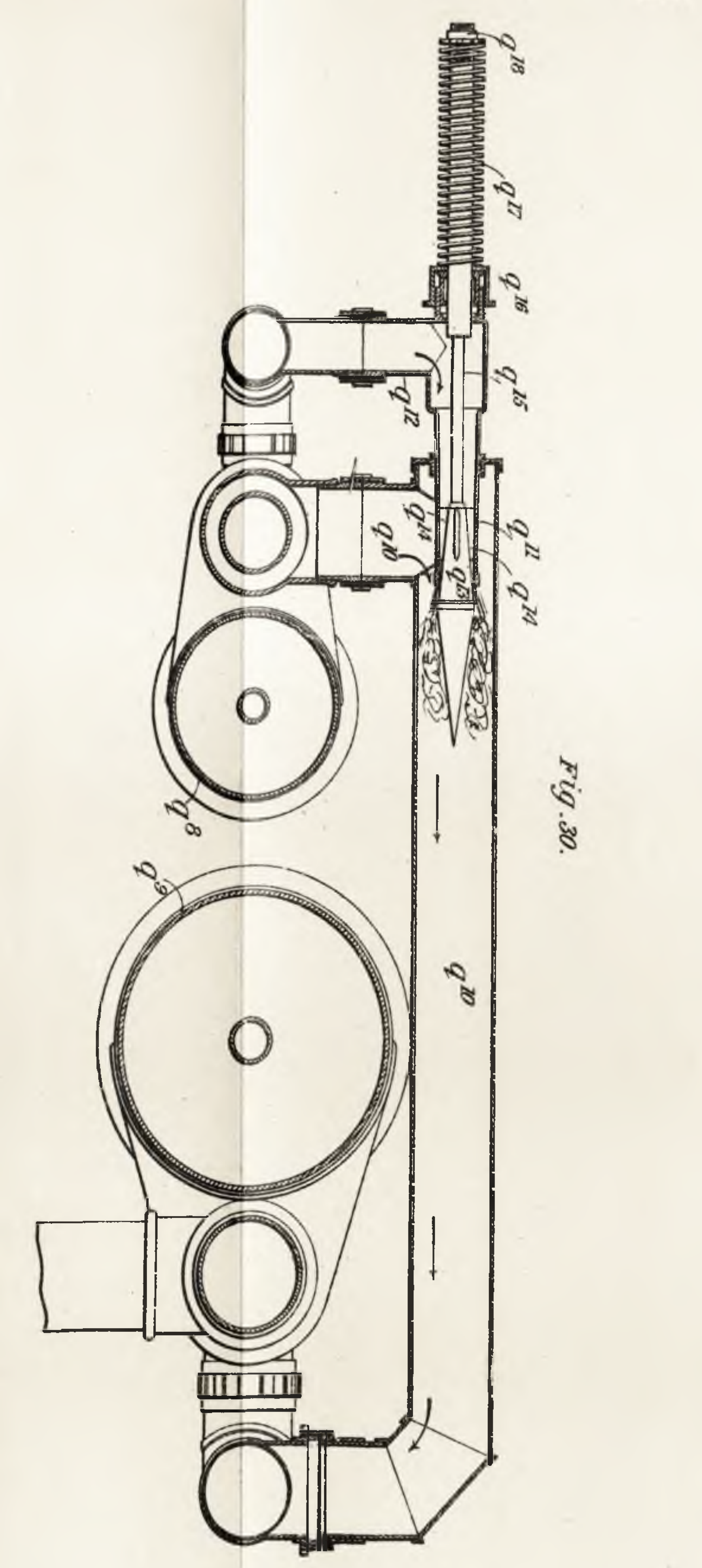

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Fig. 32.

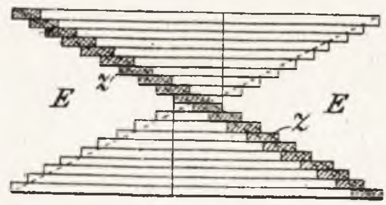

Fig. 17b

Fig. 31.

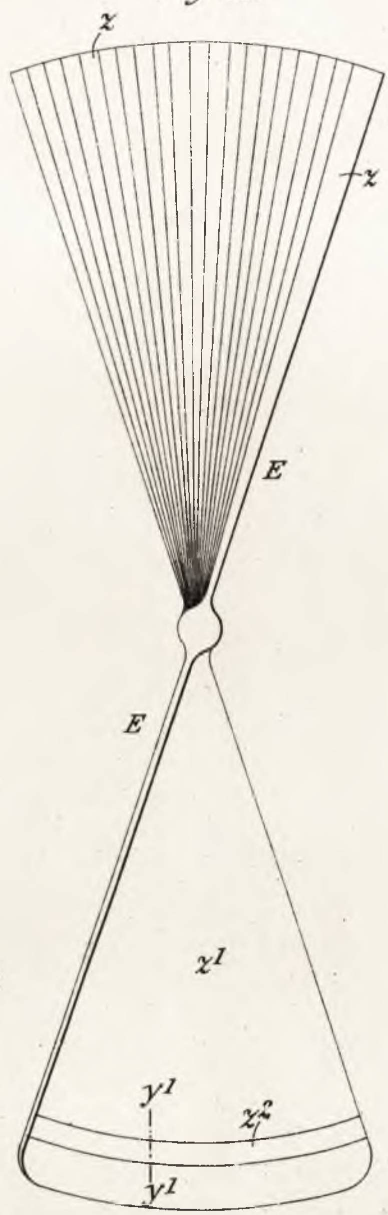

Fig. 17a

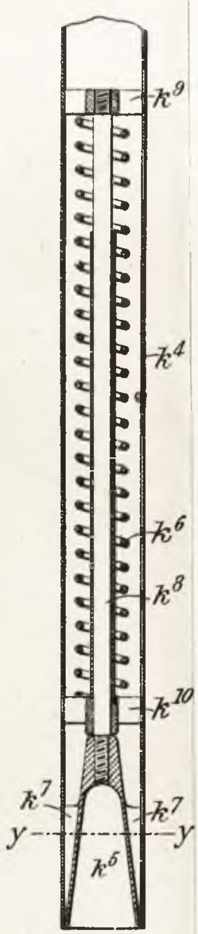

Fig. 31a

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[Third Edition.]

N° 3608 A.D. 1897

Date of Application, 10th Feb., 1897

Complete Specification Left, 10th Dec., 1897—Accepted, 10th Feb., 1898

PROVISIONAL SPECIFICATION.

Improvements in and relating to Aerial Machines.

I, Frederick William Lanchester, of Cobley Hill, Alvechurch, in the County of Worcester, Engineer, do hereby declare the nature of this invention to be as follows:—

My invention relates to improvements in machines for the purpose of aerial locomotion and navigation, and refers more particularly to the construction of a machine specifically heavier than the atmosphere that shall be able to traverse the air in any desirable direction, either under the control of an aeronaut or otherwise.

Part of the present invention has for its object to provide means whereby both the lateral and fore and aft stability of the machine is automatically secured; other portions relate to the form and structure of the supporting surfaces and propellers, and to the launching and controlling arrangements.

In constructing a machine in accordance with the present invention, I arrange a body of elongated and preferably stream line form of suitable dimensions to contain the propelling and other mechanism, and to provide sufficient accommodation for whatever purpose required. I also provide two rigidly attached wings, one extending horizontally on each side of the said body. These wings are constructed in the manner hereinafter to be described, and are so arranged as to bear the whole or a greater proportion of the weight of the machine by the reaction of the air in its vicinity. Attached to the after extremity of the body, or to a prolongation thereof, I arrange a horizontal plane which will be hereinafter referred to as the "tail plane" and which may either consist of a thin plate of light wood or other material, or may be built or framed up and covered with suitable material, and may be somewhat curved or quite flat, according as it is arranged to support a portion of the load or otherwise. From the centre line of the body, or from the aforesaid prolongation thereof, I arrange fins projecting upwards. These fins may be constructed in the same manner as the tail plane and are preferably arranged some distance apart and so that their combined centre of pressure is somewhat aft of the centre of gravity of the machine.

For the purpose of propulsion a motor of any known type may be employed to drive a screw propeller or propellers after the manner of a steam vessel, but I prefer to arrange a gas or oil motor (or a pair of such motors) of the type in which the energy of each explosion is communicated to two oppositely rotating parts in order to relieve the machine from unbalanced recoil, and prevent vibration. I prefer to construct the propellers after the manner of cycle wheels, the rims being constructed of flat strips of sufficient weight to act as flywheels for the motor, the blades of the propellers being formed by means of fabric or thin plate stretched or otherwise fitted between suitably arranged pairs of spokes.

The form or wing employed to support the weight of the machine is preferably that of the soaring bird, that is to say of great lateral breadth and small fore and aft dimension, with a convex upper and a concave under surface, the intensity of the curvature diminishing and the plan contour of the wing tapering towards its extremity.

[*Price* 8*d*.]

In one mode of constructing a wing in accordance with the present invention, I arrange a steel tube extending for about half the length of the wing, suitably trussed, and carrying at its outer extremity a vertical cross pillar from the ends of which wire stays are run out to all outstanding points of a skeleton structure which in its turn attaches to the main tube. The steel tube and skeleton structure are included between the upper and under surfaces of the wing which may be of silk or other fabric, or thin sheet aluminium or other metal may be used. When fabric is employed, it is preferable to arrange the fabric of the upper surface of closer texture than that of the under, or a coat of varnish may be applied in order that it may bulge properly when the machine is in motion.

The extremities of the wings may be capped by "planes" arranged normally to the wing surfaces and conformably to the direction of flight, in order to minimise the lateral dissipation of the supporting wave.

In order to control the course of the machine vertically,and also its velocity,suitable gear is arranged to alter the angle made by the wings as a whole, and the tail plane, relatively to one another, and also to vary the speed of the motor as desired. For each angle of the tail plane relativelyto thewings there is a corresponding "proper velocity" for the machine which it automatically seeks in the resulting alteration in its course going downwards to increase its velocity, and upwards to diminish it, and though the immediate effect of an alteration in the angle of the tail plane is to alter the course of the machine, its ultimate effect is to alter the velocity. A permanent alteration in the course can, however, be effected either upward or downward by respectively increasing or decreasing the thrust of the propellers, which may be done by varying the speed of the motor.

Instead of making an alteration in the angle of the tail plane, the same result can be obtained by shifting the centre of gravity of the machine forward to increase the "proper velocity," and backward to diminish it.

The lateral steering may be effected by means of a rudder as with a boat, or one of the fins may be used as a rudder and actuated by suitable mechanism, or an alteration in the angle of the two wings relatively to one another or parts of them will by giving a list sideways to the machine effect an alteration in its course.

In launching an aerial machine in accordance with the present invention, a slip is arranged consisting of a pair of parallel wire ropes suitably stretched, on which the machine runs either by its own weight and propulsion or by cable traction. The machine is prevented from jumping the track by cord lashings, the latter being cut away by fixed knives, as the machine leaves the slip.

Dated this 10th day of February, 1897.

MARKS & CLERK,
18, Southampton Buildings, London, W.C., and
13, Temple Street, Birmingham, Agents.

COMPLETE SPECIFICATION.

Improvements in and relating to Aerial Machines.

I, Frederick William Lanchester, of Cobley Hill, Alvechurch, in the County of Worcester, Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

My invention relates to improvements in machines for the purpose of aerial locomotion and navigation and refers more particularly to the construction of a machine specifically heavier than the atmosphere that shall be able to traverse the air in any desirable direction, either under the control of an aëronaut or otherwise.

Part of the present invention has for its object to provide means whereby both the lateral and fore and aft stability of the machine is automatically secured; other portions relate to the form and structure of the supporting surfaces and propellers, and to the launching and controlling arrangements.

In constructing a machine in accordance with the present invention, I arrange a body of elongated and preferably stream line form of suitable dimensions to contain the propelling and other mechanism—and to provide sufficient accommodation for whatever purpose required, I also provide two rigidly attached wings one extending horizontally on each side of the said body. These wings are constructed in the manner hereinafter to be described, and are so arranged as to bear the whole or a greater proportion of the weight of the machine by the reaction of the air in its vicinity. Attached to the after extremity of the body or to a prolongation thereof, I arrange a horizontal plane which will be hereinafter referred to as the "tail plane" and which may either consist of a thin plate of light wood or other material, or may be built or framed up and covered with suitable material and may be somewhat curved or quite flat, according as it is arranged to support a portion of the load or otherwise. From the centre line of the body, or from the aforesaid prolongation thereof, I arrange fins projecting upwards. These fins may be constructed in the same manner as the tail plane and are preferable arranged some distance apart and so that their combined centre of pressure is somewhat aft of the centre of gravity of the machine.

For the purpose of propulsion a motor of any known type may be employed to drive a screw propeller or propellers, after the manner of a steam vessel, but I prefer to arrange a gas or oil motor (or a pair of such motors) of the type in which the energy of each explosion is communicated to two oppositely rotating parts in order to relieve the machine from unbalanced recoil, and prevent vibration. I prefer to construct the propellers after the manner of cycle wheels, the rims being constructed of flat strips of sufficient weight to act as flywheels for the motor, the blades of the propellers being formed by means of fabric or thin plate stretched or otherwise fitted between suitably arranged pairs of spokes.

The form of wing employed to support the weight of the machine is preferably that of the soaring bird, that is to say, of great lateral breadth and small fore and aft dimension with a convex upper and a concave under surface, the intensity of the curvature diminishing and the plan contour of the wing tapering towards its extremity.

In one mode of constructing a wing in accordance with the present invention, I arrange a steel tube extending for about half the length of the wing, suitably trussed, and carrying at its outer extremity a vertical cross pillar from the ends of which wire stays are run out to all outstanding points of a skeleton structure which in its turn attaches to the main tube. The steel tube and skeleton structure are included between the upper and under surfaces of the wing which may be of silk or other fabric, or thin sheet aluminium or other metal may be used. When fabric is employed, it is preferable to arrange the fabric of the upper surface of closer texture than that of the under or a coat of varnish may be applied in order that it may bulge properly when the machine is in motion.

The extremities of the wings may be capped by "planes" arranged normally to the wing surfaces and conformably to the direction of flight, in order to minimise the lateral dissipation of the supporting wave.

In order to control the course of the machine vertically, and also its velocity, suitable gear is arranged to alter the angle made by the wings as a whole, and the tail plane, relatively to one another, and also to vary the speed of the motor as desired. For each angle of the tail plane relatively to the wings there is a corresponding "natural velocity" for the machine which it automatically seeks in the resulting alteration in its course going downwards to increase its velocity, and upwards to diminish it, and though the immediate effect of an alteration in the angle of the tail plane is to alter the course of the machine, its ultimate effect is to alter the velocity. A permanent alteration in the course can, however, be effected either upwards or downward by respectively increasing or decreasing the thrust of the propellers which may be done by varying the speed of the motor.

Instead of making an alteration in the angle of the tail plane, the same result can be obtained by shifting the centre of gravity of the machine forward to increase the "natural velocity," and backward to diminish it.

The lateral steering may be effected by means of a ruder as with a boat or one of the fins may be used as a rudder and actuated by suitable mechanism, or an alteration in the angle of the two wings relatively to one another or parts of them will by giving a list sideways to the machine effect an alteration in its course.

In launching an aerial machine in accordance with the present invention, a slip is arranged consisting of a pair of parallel wire ropes suitable stretched, on which the machine runs either by its own weight and propulsion or by cable traction. The machine is prevented from jumping the track by cord lashings, the latter being cut away by fixed knives, as the machine leaves the slip.

Referring to the accompanying sheets of illustrative drawings in which the same alphabetical letters are used for like parts throughout, *a*, *a*, are the wings arranged to support the whole or a greater portion of the weight of the machine; *b* is the tail-plane, *c*, and *d*, are the upwardly projecting fins; *e*, is the wing capping plane; and *f*, and *g* are respectively the blades and rim of the novel form of fly-wheel propeller that I preferably employ. The motor is denoted by the letter Z and the "cage" or car by the letter Y.

Referring in detail to Sheet (1).—Figures 1, 2, and 3, represent respectively a side and end elevation and plan of an aerial torpedo constructed in accordance with the present invention, the propelling mechanism, Z, *f*, *g*, is shown somewhat diagramatically and may be dispensed with altogether when only a moderate range is required. In machines of moderate dimensions the wings *a*, *a*, may be cut from a single piece of pine or other light wood and the plan form is preferably elliptical or thereabouts as shown in Figure 3 and of gradually changing sectional form towards the extremities, a series of suitable sections being shown in Figure 6 in which the mean surface of curvature of the central section is shown as a dotted line throughout; I find it advantageous thus to diminish the steepness of curvature towards the wing extremities also to so arrange that the front edge "dips" considerably relatively to the direction of motion which in Figure 6 is presumed to be across the paper from right to left. Figures 4 and 5, show a modified form of wing truncated and provided with the capping plane *e*, the function of these being to minimise the loss of energy due to air circulation round the wind extremities. The proportion of major to minor axis I find most desirable in the elliptical form of wing is from 10; I to 13; 1, a greater ratio would be theoretically preferable but practical considerations have to be taken into account. A single fin (shown dotted Figure 1) *c*, of sufficient length may be substituted for the two separate fins *c* and *d*.

Figures 7, 8, and 9, show in end and side elevation and in detail, portions of a launching apparatus constructed in accordance with the portion of my present invention relating thereto. In the act of launching the machine is arranged to run on tight wires or cords, being tethered thereto by lashings as shown in Figure 9 the machine has its initial velocity imparted to it by any suitable mechanism such as a cable actuated by a winding engine, or in some cases a catapult may be used in which stretched caoutchouc is employed to store up the energy required. The wires at their extremities pass over two end frames and are secured beyond in any suitable manner, on the front frame (Figure 7) are carried two cutter blades *i*, *i*, of the form indicated and are so arranged as to cut the lashings as the machine leaves its cradle.

Referring to Sheet 2.—Figures 10, 11, and 12, illustrate a machine designed for the purposes of aerial navigation and in this arrangement a tubular rectangular framework k^1, k^1, is built up, the side *k*, *k*, forms the "back bone" of the wing structure and is extended to *m*, *m*, the right and left hand wings are shown in the figure of alternative design, the left hand wing is shown of truncated form and fitted with a capping plane, the right hand wing is shown of tapering form and is built up of a framework covered with a suitable fabric to give a configuration as closely as possible resembling that indicated by Figure 6 already referred to. At the point *m*, a vertical strut is inserted forming at its extremities points of attachment for a number of wire stays connecting up to all outstanding portions of the wing framework, Figure 11. The rear portion of the main framework *l*, *l*, may conveniently be made to form part of the structure of the tail plane as shown in Figure 12, one method of framing up the wings, tail plane, and fins is illustrated in Figure 17, in which the detail of a fin is shown on a larger scale and will be hereinafter referred to at greater length.

I preferably use a motor of my two crank balanced type, this is figured Z, Z, in Figures 10, 11, 12, and is carried off brackets attached to the two side tubes of the main framework, the two propellers the construction of which will be further described are right and left hand to correspond with the reversed rotation of the two shafts. The motor itself is as far as possible enclosed in a casing of stream-line form, but the cylinders are preferably exposed to the cooling action of the air in the case of motors of the internal combustion type.

Accommodation for the aeronaut and any accessories to the use of the machine is provided in the "cage" or car-body Y which is arranged well forward so as to bring the centre of gravity of the machine sufficiently near to the centre of pressure of the supporting surfaces; the actual construction of the car body admits of considerable latitude; woodwork, basket-work, or other suitable material may be employed but as far as practicable a stream-line form should be adopted.

Provision is shown for steering and for altering the natural velocity of the machine; the steering mechanism is arranged to actuate the two rearmost fins (Figures 13, and 14) these are coupled together by a link *u* and are operated upon by a bell crank lever *w* and actuating link *v* the latter connecting to suitable operating mechanism in the car. The gear shown for effecting an alteration in the natural velocity of the machine consists of a cross strut *s* attached to the tail plane and a tension cord *t*, *t*, *t*, fastened to the structure of the tail plane and carried forward to the bobbin *x* and thence actuated by gear within the car, the tail plane in this arrangement being allowed a certain amount of angular movement about its points of attachment. If desired however steering or the alteration of the natural velocity may be done either wholly or in part by shifting ballast, or by the movement of the aeronaut himself, the centre of gravity of the machine being thrown laterally in the direction in which it is desired to steer or by moving forward to increase or backward to diminish the natural velocity.

Referring to Sheet 3.—Figures 15 and 16, show in section and elevation one mode of constructing a combined fly-wheel and screw propeller in accordance with the present invention. The rim is preferably made of wood and is securely spoked and built on to a cast boss as shown, tangent spokes are arranged to render the wheel sufficiently rigid to act as a fly-wheel and further spokes are fitted at suitable intervals to which fabric "sails" are laced or otherwise attached to form the vanes *f*, *f*, *f*, but these vanes may be formed by carving out of wood or other material if desired. A tapering extremity may be given to the propeller boss by fitting to it a tent like structure as depicted in the figure.

The rim *g* is able in certain cases to either supplement or even supplant the tail-plane and rear fin by virtue of the great resistance it offers to lateral motion in any direction; for instance in Figures 1, 2, and 3, (Sheet 1) when a propeller, such as that shown, is employed the fin *d* and tail-plane *b* could be dispensed with, though it might be found advantageous to somewhat increase the width of the rim *g* in that case. A further advantage possessed by my new propeller is that the flat form of rim acts to a certain extent to increase the efficiency of the blades bearing the same relation to them that the capping planes do to the supporting wings.

When a single propeller is employed as in Figures 1, 2 and 3, a small weight may be arranged to balance the turning moment due to the reaction of the propeller and mechanism.

Figures 17 and 18 to which reference has already been made illustrate a method of construction for the fin framework, also applicable to the tail-plane and wings;

the drawing represents one of the fins divested of its external covering, a tubular socket *o* is built on to the framework of the machine and carries a wooden blade *p* which is capped by a sheet metal socket *q*, this cap carries studs in its lower corners over which pass the wire stays *r*, *r*, and *r*, *r*, tightened by nipples fitted to one of the main tubes in the manner shown.

It may be briefly stated that in a machine constructed as herein described the tail-plane acting in conjunction with the supporting wings has for its principal functions the preservation of longitudinal equilibrium and the regulation of speed, whilst the fins are concerned with the maintenance of transverse equilibrium and control of geographic direction, the inclination of the course to the horizontal is under the control of the propeller thrust.

The behaviour of the machine under different conditions and the function of its various parts will be better understood from the following explanatory description.

When a machine constructed as hereinbefore described travels through the air with a sufficient velocity its weight is supported dynamically by the reaction of the air on the upper and under wing surfaces, the curved form of section developing a region of pressure beneath and rarefaction above in the same manner as a simple inclined plane but with the advantage of greatly reduced resistance in the line of motion. Now if the velocity of travel is insufficient the air reaction will be deficient and if the velocity be excessive the air reaction becomes greater than the weight of the machine and consequently there is for any particular adjustment of a machine a certain speed at which its weight will just be buoyed up so that (so long as this critical speed be maintained) its centre of gravity will continue to move in a straight line, that is to say that at this speed (which has already been referred to as the "natural velocity") there is no tendency of the course of the machine to change. Now let us suppose that a machine without motor be launched horizontally at its "natural velocity" then at first no change in its direction of motion takes place, but as its velocity falls owing to the resistance of the air (frictional and otherwise) it gradually assumes a course inclined downwards and after some oscillation finally settles down to such an inclination as will by its descent enable it to be supplied with the energy necessary for its propulsion, the steepness of the descent under given conditions depends upon the rate of dissipation of energy by the resistance of the machine this angle may be termed the angle of "recuperation." If now we suppose the machine to be launched at a speed considerably above its natural velocity, then in the first instance it takes an upward course of gradually increasing inclination till its excess of kinetic energy has been absorbed as potential, the inclination of its course then gradually diminishes till it again becomes horizontal, when, its velocity having become considerably deficient its course takes a downward trend and thus it proceeds to describe curves in the air of approximately trochoidal form of gradually diminishing amplitude slowly settling down to its angle of "recuperation." If the launching velocity be excessive (greater than $1\frac{1}{2}$ times the natural velocity in most cases) the machine runs a serious risk of being capsized and the limit of longitudinal stability may be said to be reached somewhere about this point.

The natural velocity of a machine may be modified at will by altering the relative angle between the wings and tail-plane, thus causing the former to meet the air at a greater or less angle.

The power of controlling the natural velocity as well as the launching velocity will in many cases permit of an aerial torpedo being successfully directed from behind a rampart or otherwise at a hidden object.

If in the course of its evolutions a machine (constructed as hereinbefore described) heel over side ways one way or the other or if a "rolling" motion be set up, the first effect is for the machine to begin to slide down, so to speak, in the direction in which it is for the time being inclined, this motion is very quickly arrested however by the resistance of the "fins" whose centre of pressure is arranged above the centre of gravity of the machine and equilibrium is thereby restored, a similar result might be brought about by inclining the wings or the tips of the wings upwards to the right and left but an arrangement of fins is specially valuable owing to its "damping" action on any side oscillations that may be set up.

It is easy to understand when a motor is employed for the purposes of propulsion that according to the magnitude of the thrust transmitted to the machine the "angle of recuperation" is diminished and if the thrust be sufficient the machine will retain its natural velocity with a horizontal course or even an upwardly inclined course and it will moreover automatically adapt itself to whatever thrust may be applied so that the effect of an increased thrust is only to increase the velocity of the machine in quite a transitory manner the final result, after the trochoidal oscillations due to the disturbance have settled down, being a change in the course of the machine in an upward direction.

Thus in order to effect a change in the course of the machine in a vertical plane I operate on the propelling mechanism by either increasing or diminishing the supply of working fluid or bysuch other means as may be appropriate to the motor employed. I may in certain cases introduce a counter thrust, instead of operating on the motor mechanism by erecting a small plane or other obstruction perpendicular to the direction of the motion of the machine so as to cause it to take a downward course. When only a temporary change of direction is required as when evading an obstacle the tail plane may be used with effect for vertical steering but only within the limits of the safe velocity of the machine.

The surfaces of the limbs (*i.e.* wings, tail-plane, and fins) of a machine, constructed as hereinbefore described, by acting on the air both support the weight of the machine and secure its stability and by their function these surfaces may be divided into "supporting" surfaces and "dirigent" surfaces and the limbs may be termed "supporting" and "dirigent" limbs accordingly. In the arrangements illustrated in the accompanying drawings the wings are the main supporting limbs the fins and tail-plane are dirigent only, the latter may however act as a subsidiary supporting limb in which case the centre of gravity is arranged somewhat aft of the wing area and the tail-plane is preferably made of a curved section in order to carry out its additional function with the least resistance possible, in order however not to infringe the necessary conditions of stability the pressure intensity on the tail-plane should be made less than that on the wing area.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. In aerial machines the method of securing stability by means of a supporting surface or surfaces and dirigent surfaces substantially as hereinbefore set forth.

2. In aerial machines whose weight is sustained by the dynamic reaction of the air on supportingsurfaces the combination of dirigent surfaces arranged and operating substantially as hereinbefore set forth with reference to Figures 1, 2, 3, and 10, 11, 12, of the accompanying drawings.

3. In aerial machines the method of permanently altering or "laying" the course of the machine in a vertical direction by increasing or decreasing the propeller thrust or by introducing a counter thrust substantially as hereinbefore set forth.

4. In aerial machines the method of varying the velocity of travel by the adjustment of the wings or main supporting limbs and the tail-plane relatively to one another or by the alteration of the position of the centre of gravity of the machine substantially as hereinbefore set forth.

5. An aerial torpedo or air borne projectile substantiallyas describedwith reference to Figures 1, 2, 3, 4, and 5, of the accompanying drawings.

6. An aerial machine comprising a tubular foursided main frame with supporting and dirigent limbs and propelling mechanism arranged and operating substantially as hereinbefore described with reference to Figures 10, 11, 12, of the accompanying drawings.

7. A combined fly-wheel and propeller constructed and operating substantially as

hereinbefore set forth with reference to Figures 1, 2, 3, and 15, and 16, of the accompanying drawings.

8. In aerial machines whose weight is sustained by the dynamic reaction of the air on supporting surfaces the arrangement of capping plane as and for the purpose hereinbefore set forth.

9. The method of launching aerial machines from a wire track in which suitable knives are arranged to cut the machine clear at the moment of discharge, as set forth.

Dated this 10th day of December 1897.

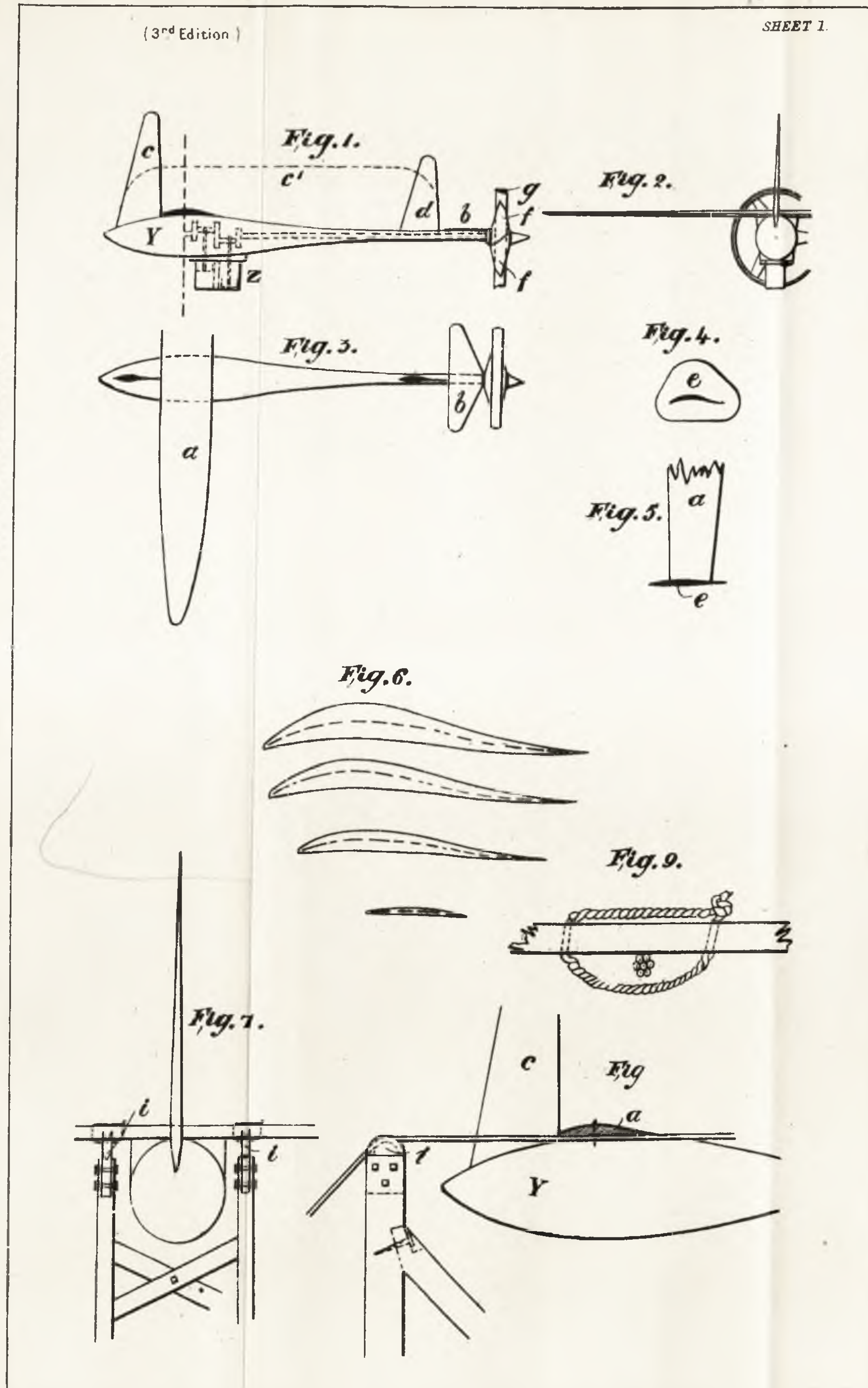
MARKS & CLERK,
18, Southampton Buildings, London, W.C., and
13, Temple Street, Birmingham, Agents.

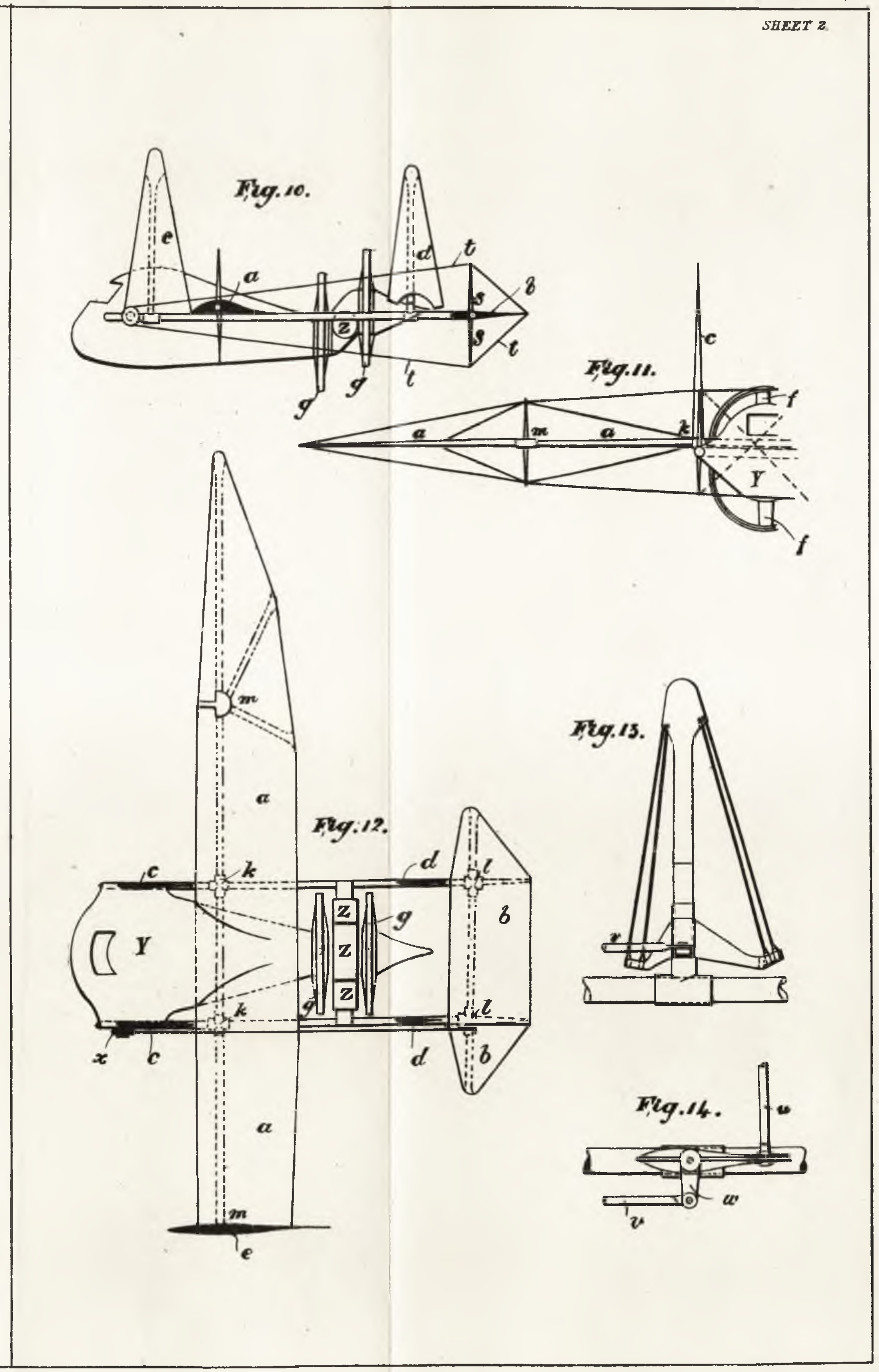
Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.
[Wt. 42—50/4/1911.]

A.D. 1897. Feb. 10. No. 3608.
LANCHESTER'S Complete Specification.

(3 SHEETS)

[This Drawing is a reproduction of the Original on a reduced scale]





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A.D. 1897. Feb. 10. N° 3608.
LANCHESTER'S Complete Specification.

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SHEET 3.

(3rd Edition)

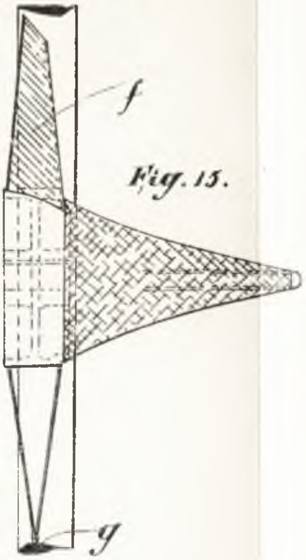

Fig. 15.

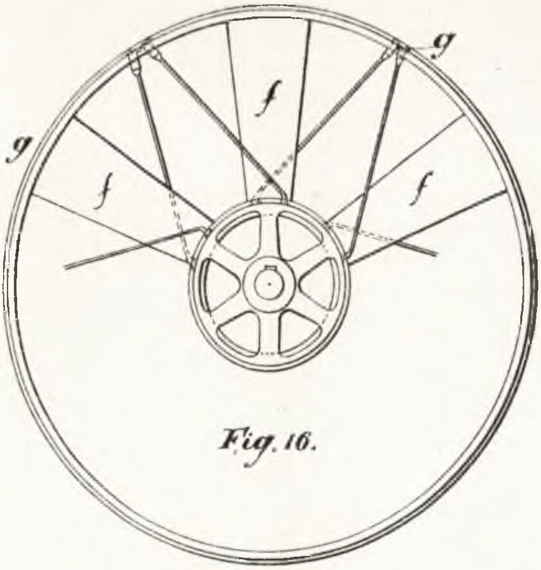

Fig. 16.

Fig. 17.

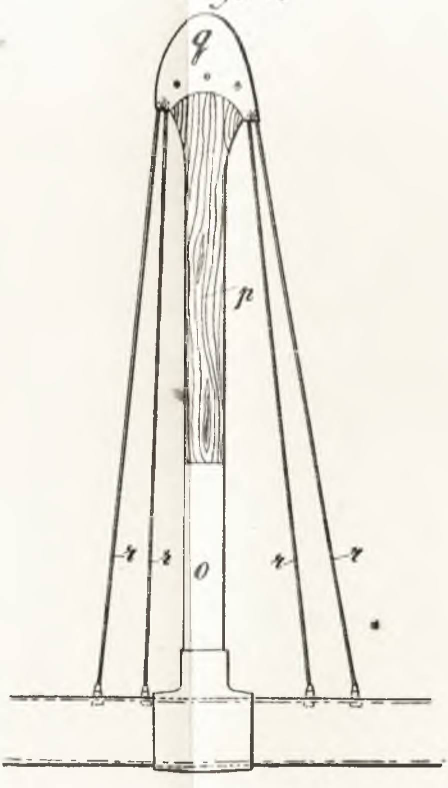

Fig. 18.

[This Drawing is a reproduction of the Original on a reduced scale.]

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Fig. 1.

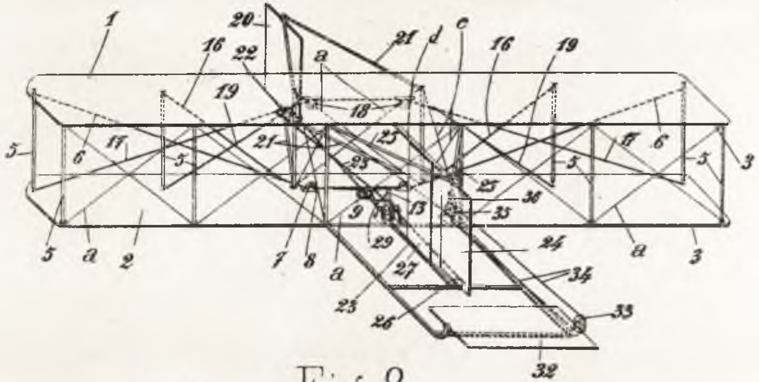


Fig. 3.

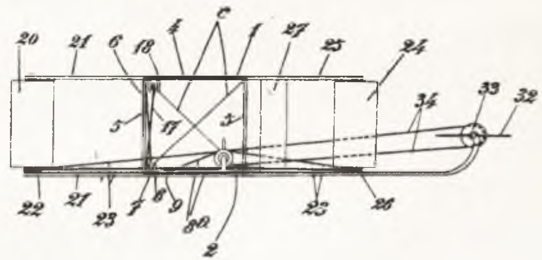


Fig. 2.

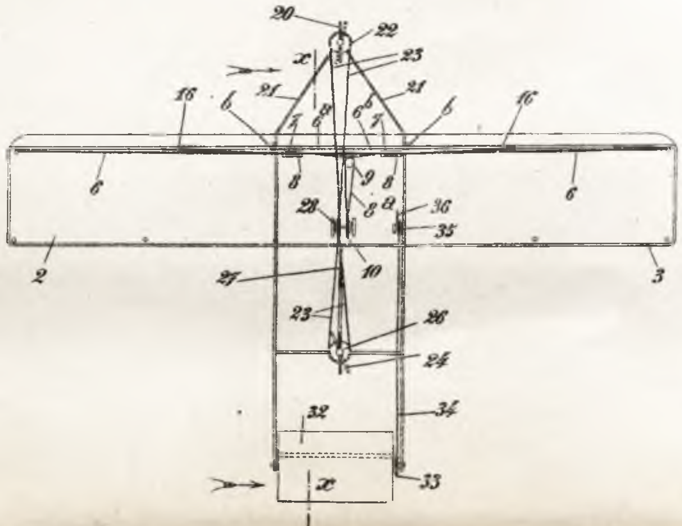
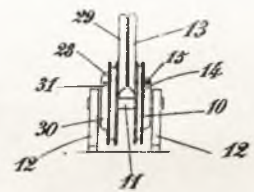


Fig. 4.



3412

Defendant's Exhibits. 1139

3415


CURTISS PHOTOGRAPH NO. 1
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CURTISS PHOTOGRAPH NO. 2
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CURTISS PHOTOGRAPH NO. 3
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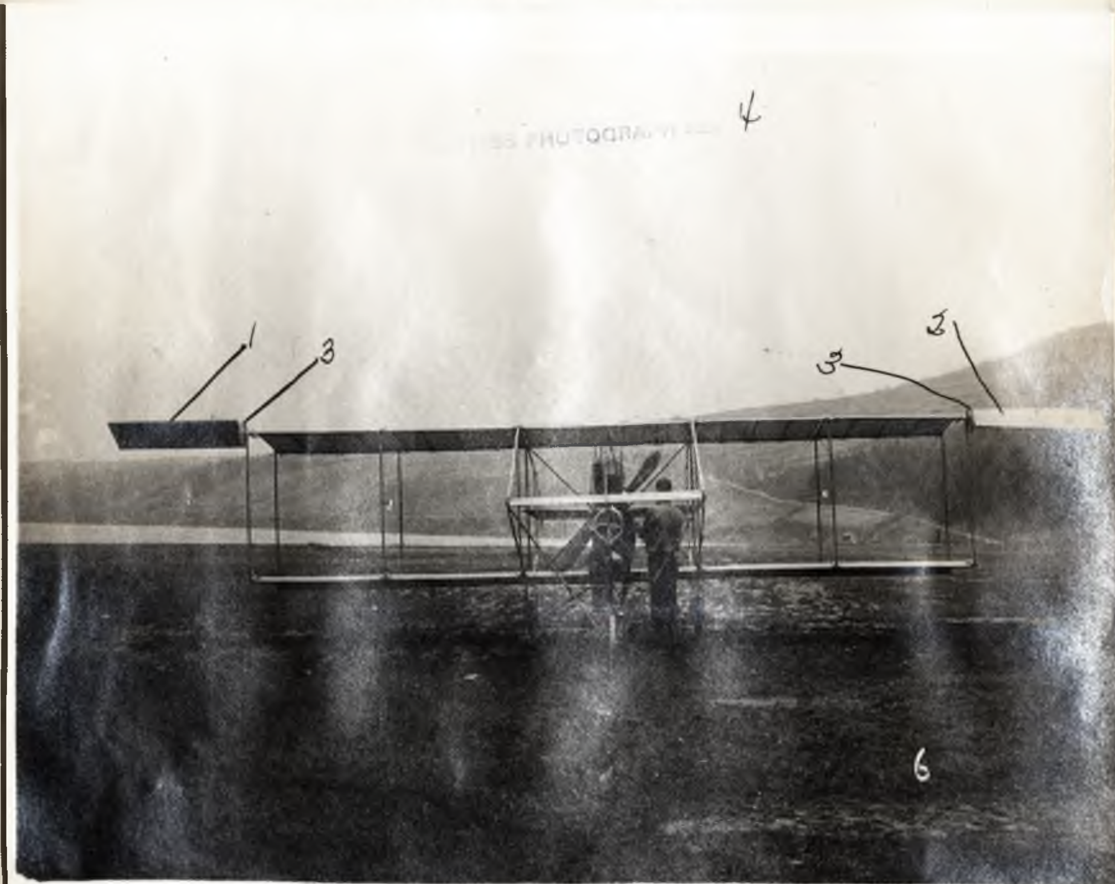
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CURTISS PHOTOGRAPH NO. 5
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ZAHM PHOTOGRAPH No. 2

Order. 3427

UNITED STATES DISTRICT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY, *v.* THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.	In Equity #400.

This cause having come on to be heard on motion by defendants, it is hereby ordered: 3428

(1) That defendants' answer may be amended by including in paragraph (11) German patent #77,036 to Gottfried Schroder, ausgegeben Oct. 4th, 1894;

(2) That complainant's replication may stand as the replication to the answer as amended; and

(3) That defendants may have until October 5th, 1912, to take testimony in regard to this patent, and complainant until October 19th to take testimony in rebuttal as to the same, and that the final hearing now set for October 16th be postponed until October 31st. 3429

Dated September 24th, 1912.

JOHN R. HAZEL,
U. S. Judge.

Counsel for complainant hereby waives production of a certified copy of the above mentioned patent, and agrees to accept in lieu thereof a printed copy with the same force and effect as though duly certified by the United States and German Patent Offices, subject to correction if found to contain error.

H. A. TOULMIN,
Counsel for Complainant.

3430 **Amendment to Answer.**

UNITED STATES DISTRICT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY, *v.* THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.	In Equity #400.

Now come the defendants herein, by their So-
3431 licitor, Emerson R. Newell, and, permission having been obtained by the order of Sept. 24th, amend their answer by inserting in paragraph (11) under the sub-title "German Patents" the following words:

"77,036 to Gottfried Schroder, ausgegeben October 4, 1894."

THE HERRING-CURTISS COMPANY and
GLENN H. CURTISS,
By EMERSON R. NEWELL,
Solicitor & Counsel for Defendants,
#2 Rector Street,
New York City,
3432 New York.

Dated, N. Y., Sept. 25, 1912.

UNITED STATES DISTRICT COURT, 3433

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY, *v.* THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.	In Equity #400.

New York, N. Y., Sept. 30, 1912.

Testimony taken in behalf of defendants in the above entitled case, pursuant to order dated Sep- 3434
tember 24th, 1912, and pursuant to notice and agreement between counsel, before Miss Beatrice Mirvis, Notary Public, commencing at 10 A. M., September 30th, 1912, at the office of Emerson R. Newell, #2 Rector Street, New York City, New York.

PRESENT:

EDWARD L. REED, for Complainant.
EMERSON R. NEWELL, for Defendants.

ALBERT STETSON, a witness introduced on behalf of defendants, having heretofore testified and been sworn in this cause, deposes and says in 3435
answer to questions by Mr. Newell:

Q1. Are you the same Albert Stetson who has heretofore testified in behalf of defendants and whose qualifications as to familiarity with the German and French languages are given on page 370 of defendants' printed record?

A. I am.

Q2. Have you read the German patent to Gottfried Schroder #77,036, issued October 4, 1894, and have you prepared a correct translation thereof?

3436 A. I have read the patent and have prepared such translation, which I here present.

Counsel for defendants introduces in evidence a copy of the patent referred to, and requests that the same be marked as "Defendants' Exhibit Schroder Patent."

He also introduces the translation presented by the witness, and requests that it be marked as "Defendants' Exhibit Translation Schroder Patent."

Cross examination by Mr. Reed:

XQ3. Is the translation which you have submitted a literal or a free translation?
3437

A. It is intended to be a literal translation.

XQ4. At the time you made this translation, had you read or were you familiar with the Wright patent in suit?

A. I have never to my knowledge read or seen the Wright patent in suit, or in fact any Wright patent.

XQ5. Were you at that time familiar with the construction and operation of either of the Wright machine or the Curtiss machine?

A. I certainly do not know the difference between the Wright and the Curtiss machine. My
3438 knowledge of flying machines is simply such as would be gained by reading popular accounts of the exploits of men managing such machines.

ALBERT STETSON.

FRANK N. WATERMAN, a witness heretofore introduced by defendants, being recalled, testifies as follows in answer to questions by Mr. Newell:

Q1. Are you the same Frank N. Waterman who has heretofore testified in behalf of defendants?

A. I am.

Q2. Have you read and do you understand the 3439
German patent to Schroder, No. 77,036, as disclosed in the drawings thereof and the "Defendants' Exhibit Translation Schroder Patent?"

A. Yes.

Q3. Please describe the construction and method of operation of the device illustrated and described in the Schroder German patent No. 77,036, discuss the same, and state whether or not, in your opinion, it discloses the combinations set forth in Claims 3 and 7 of the patent in suit, if said claims are interpreted broadly enough to include defendants' machine?

A. The Schroder patent is entitled "Airship 3440
with Device for Maintaining the Wedge-Shaped Balloon in Horizontal Position," and special emphasis is laid in the specification upon the maintenance of lateral equilibrium by the action of lateral control "wings," or as they would now be called, ailerons.

At the date of the patent, namely, 1894, engines light enough for aeroplane purposes were not to be had, and the patentee has therefore built a wedge-shaped balloon structure on the top of the aeroplane, so to speak, and of a form intended to give low air resistance while furnishing supporting power to carry the weight of the machinery. 3441
As I understand the matter therefore, the device is not intended to be strictly of the heavier-than-air-type, but is designed to approach in form as closely as possible to that type, and the underside of the wedge-shaped balloon is arranged to constitute a normally flat aeroplane surface such as is referred to in the Wright patent and particularly recited in Claim 3.

Referring to the drawings, Fig. 1 illustrates the entire structure as it would be seen in the air by an observer to the left of its line of progress

3442 and to the rear. The wedge-shaped balloon is indicated at a and moves with the sharp edge of the wedge forward, the under side acting as an aeroplane surface. Suspended from the central line of this surface is a wedge-shaped car b which hangs free to swing on depending links e, as shown in Figs. 1 and 2. This car contains the motive power and drives a pair of propellers having blades d, as shown in each of the six figures. Referring to Fig. 3, d'', is the shaft giving motion to the propellers, and d', d' are propeller arms carrying blades d. Figs. 3, 4, 5 and 6 are devoted to the illustration of the construction and mode
3443 of operation of the propeller blades which are spring-mounted on their arms, and the specification describes the adjustment of the springs in order that the blades will automatically adjust their "pitch" angles so as to give the most efficient propulsion at all speeds. Fig. 6 illustrates how the relation of air movement to the propeller blades varies with different speeds. One propeller is mounted on each side of the car b at the rear thereof, the bearings for the same being indicated at g, g.

At the rear of the car there is mounted a vertical rudder c' carried on a vertical pivot shaft
3444 l in bearings k. This shaft l carries a cross-piece l' terminating in bearings l'' in which there is pivoted a horizontal shaft m for a horizontal rudder c. Thus the horizontal rudder c and the vertical rudder c' constitute a double rudder device arranged to turn about a vertical pivot for steering to the right or left, and about a horizontal pivot for steering up and down.

The method of control of these two rudders is extremely simple and practical. Each end of the horizontal rudder shaft m is turned vertically upward to form control arms m', and another control arm m'' projects downward at the middle. Within the car there is a precisely similar arrangement comprising the vertically pivoted shaft l, the horizontally pivoted shaft m, the upwardly extending arms m' and the downwardly extending arm m''. The ends of the arms within the car are connected with those of the rear of the car by ropes n, n', and there is a hand lever c connected to the shaft m within the car. 3445

Thus it will be seen that the rudder can turn to the right or left to turn the airship to the right or left, and can swing up and down to 3446
similarly steer the airship in a vertical plane, and this is accomplished by the movement of the single control handle. If the operator desires to point the airship upward, he moves the control lever c upward; if he wishes to descend, he moves the control lever downward. Similarly if he wants to go to the right, he moves the lever to the right; or if he desires to turn to the left, he will move the lever to the left.

To preserve the lateral equilibrium, that is to correct the tendency of the machine to tip over sidewise, there is provided a pair of ailerons o
mounted one at each side extremity, upon hori- 3447
zontal shafts a' carried in bearings p fastened to the under-surface of the balloon. As best seen in Fig. 2, each aileron shaft has a forwardly-extending horizontal arm a'', and the forward extremity of each of these two arms is connected by links q to a pair of arms f', f' rigidly fastened to the car.

Thus the ailerons themselves are pivoted in supports rigidly attached to the aeroplane surface of the balloon, but they are linked by bell-

3448 crank arms to the pivoted car. By tilting the car to one side or the other the planes *o, o,* will be tilted.

Observing carefully the mechanical connections as shown in Fig. 2, it will be seen that if the aeroplane tilts to the right the car will swing to the right with respect to the plane (in order to always hang vertical). Since the ailerons are attached to the underside of the balloon by the bearings *p,* this relative tilting of the car will tilt the forward edge of the right-hand wing or aileron upward, and the forward edge of the left-hand aileron downward an equal extent, thus af-
3449 fording a lifting force on the right or assumed low side, and a depressing force on the left or assumed high side.

Similarly it is manifest that the operator can control the position of these ailerons by swaying his body from side to side, and that to correct a tendency to tip over sidewise, the operator has only to move toward the high side. This would tilt the car with respect to the plane and operate the aileron. I note that as clearly shown in Fig. 2, the ailerons are mounted somewhat in advance of the center of surface so as to tend to automatically assume the horizontal or idle position.
3450 There is thus shown a pair of balanced ailerons controlled automatically by the tipping of the machine and by the natural movement of the operator toward the high side to give complete control of lateral equilibrium.

There is thus disclosed in this Schroder patent a flying machine in which, by the use of one hand and the movement of the body from side to side, the operator has complete simultaneous control of a vertical rudder, a horizontal rudder, and a pair of lateral equilibrium wings or ailerons.

The machine is also provided with an aeroplane 3451
surface and with two rear propellers. Of course
it goes without saying that the ailerons could, if
desired, be controlled entirely by hand, without
added invention, such control means being old in
the art. Thus if the operator desired to have
the car rigid, no change in the Schroder machine
would be required except to fasten the car rigid-
ly and pivot the arms f', f' to it and attach a
hand lever.

I call attention to the fact that there are com-
bined in this machine all of the control means
found in the defendants' machine, acting and
arranged to be operated in substantially the same 3452
way as in defendants' machine.

Comparing with Claim 3 of the Wright patent in
suit, I find in this structure of the Schroder pat-
ent in a flying machine a normally flat aeroplane,
namely, the under-surface of the wedge-shaped bal-
loon. This aeroplane has lateral marginal portions
capable of movement to different positions above
or below the normal plane of the body of the aero-
plane, if this language can be interpreted as ap-
plying to pivoted ailerons, which are not in the
aeroplane surface at all and are not, in any ordi-
nary sense, portions thereof. In other words, if
this language of Claim 3 can apply to the defend- 3453
ants' construction, it must, in my opinion, apply
with like meaning and effect to the structure of
the Schroder patent, since the defendants' con-
struction is identical with that of the Schroder
patent, so far as concerns these ailerons. I find
further that the motion of the ailerons of the
Schroder patent is about an axis transverse to the
line of flight, whereby these marginal portions,
if such they may be called, may be moved to dif-
ferent angles relatively to the normal plane of
the body of the aeroplane, and also to different

3454 angles relatively to each other so as to present to the atmosphere different angles of incidence. I find also in the Schroder structure means for simultaneously imparting such movement to said lateral marginal portions. To prevent misunderstanding, I will repeat what I have said in my former deposition, that in my opinion such ailerons as the defendant employs and as are shown in this Schroder patent, are not properly described as the lateral marginal portions of Claim 3, because they are different structures and operate in a different way from the marginal portions of the aeroplanes of the Wright patent. In so far, however,
3455 as this language applies to the defendants' structure, it seems clear that it equally applies to the Schroder structure. This operation of the ailerons and the means for simultaneously controlling them is fully and clearly described in the Schroder patent. For the sake of completeness I here quote the last paragraph of the specification as rendered in the translation in evidence:

> "In order to hold the balloon constantly horizontal in the lateral direction, the wings *o* are attached beneath the balloon to both sides of the car. These with their shafts *o*′ turn in the bearings *p* fastened to the balloon.
> 3456 The shafts *o* have each a lever o″ directed forward, which are connected with the levers *f*′ of the forward link piece *f* by the connecting pieces *q* (Figs. 1 and 2). Should, perhaps, the right side of the balloon be inclined downward, then the right wing *o* connected with it and its lever are also carried downward. Since the car, however, does not follow this dip, the two levers f′ also do not follow this dip. The end of the right lever o″ would have to separate

> from the pivot of the right lever f′. This, 3457
> however, cannot happen, because the two are connected. The end of the right lever o″ must, consequently remain at the same height, while the wing goes downward with the balloon. Thereby, the right wing *o* so adjusts itself that the air current coming from the front hits the underside obliquely, whereby, a pressure upward is exerted. The left wing *o* will assume the opposite position, for, since, on the dipping of the balloon to the right, its left side, and with it the left wing *o* is raised, then the end of the left
> lever o″ would have to approach the pivot 3458
> of the left lever f′. Since, however, this cannot happen, because they are both connected, the left wing o″ will so adjust itself that the air current coming from the front meets its upper side obliquely, whereby, a pressure is exerted downwardly. The balloon is, therefore, on the right pressed upward, on the left downward. As soon as it returns to the horizontal position, the wings again set themselves straight. If the balloon should dip to the left, then the wings would exert the opposite action. The wings
> have, therefore, the purpose of holding the 3459
> balloon in equilibrium."

I note that the single claim which the patent contains is addressed particularly to these lateral control wings or ailerons. It reads as follows·

> "Airship with wedge-shaped balloon, which latter (a) is held in horizontal position thereby, that two surfaces (o, o) adjustable as regards the horizon, arranged at the side of the car (b) on the balloon, on lateral dipping of the balloon, are adjusted in

> 3460 opposite directions by means of rods f', q, o'' by the car (b) which hangs always vertically downward, on two pivots parallel to the longitudinal axis of the balloon, so that the wind pressure on these surfaces tends to rotate the balloon in one and the same direction."

As I pointed out, the car is pivoted and the operator has control of the angle which it assumes with reference to the balloon or aeroplane surface by moving his body from side to side.

Comparing the Schroder structure with Claim 7, I find in a flying machine the combination with
3461 an aeroplane, and means for simultaneously moving the lateral portions thereof into different angular relations to the normal plane of the body of the aeroplane and to each other, so as to present to the atmosphere different angles of incidence (being the ailerons *o* and the several connecting elements by which they are operated as above described), of a vertical rudder, and means whereby said rudder is caused to present to the wind that side thereof nearest the side of the aeroplane having the smaller angle of incidence and offering the least resistance to the atmosphere, substantially as described in the Wright patent, if that language of Claim 7 can
3462 apply to the defendants' machine. As I understand the evidence in this case, the defendants' machine has no automatic means whereby the rudder is caused to present to the wind that side thereof nearest the side of the aeroplane having the smaller angle of incidence. As I further understand the record, the defendants' machine has no need of any such arrangement. The same is true of the Schroder machine. Like the ailerons of the Curtiss machine, the ailerons of the Schroder machine would not normally offer less resistance on one side than on the other when in use to control

equilibrium. Like the Curtiss machine these ailerons are controlled by the operator (and also, in the Schroder machine, automatically), while the vertical rudder is controlled purely by hand. If, however, this language of Claim 7 can in any sense apply to the defendants' machine, then it must equally apply to the ailerons and vertical rudder of the Schroder machine, since the two are identical in all substantial respects. 3463

In view of the foregoing comparison I am of the opinion that Claims 3 and 7 are fully met by the structure of the Schroder patent in so far as said claims can be construed as descriptive of the defendants' machine, since there is combined in 3464
the Schroder machine a pair of equilibrium-controlling wings or ailerons, a horizontal rudder, and a vertical rudder, all constructed and arranged substantially as in the defendants' machine, and designed to operate in substantially the same way, to effect the same results.

Direct Examination Closed.

Recess for Lunch.

Resumed at 2 P. M. 3465

Cross examination by Mr. Reed:

XQ4. Will you please quote that portion of specification of the Schroder patent which states that "the underside of the wedge-shaped balloon is arranged to constitute a normally flat aeroplane surface?"

A. The matter is not specifically described in the Schroder patent, and I stated it as an obvious characteristic of the structure, and not as something specifically described.

3466 XQ5. Do you find in the patent any suggestion whatever that Schroder contemplated the operation of the underside of the balloon as an aeroplane?

A. Nothing except the obvious suggestion which the form of the balloon itself makes. To make my meaning clear I should call attention to the fact that a spherical or cylindrical form is the natural form of a gas-container, both because of the simpler construction and the natural equlization of pressure which results. The fact that the patentee shows a long wedge-shaped structure with a substantially flat under-surface, of itself makes it
3467 certain that such structure was provided in view of its aeroplane action.

XQ6. As a matter of fact, then, there is no basis in the specification for your assumption that the underside of the balloon functions as an aeroplane, is this correct?

A. There is, as I have said, no specific statement in the specification one way or the other. The conclusion is, however, I think the necessary one from the structure as shown and described.

XQ7. Wherever the specification makes reference to the wedge-shaped structure, it is referred to as "a balloon" and treated as having the functions of
3468 a gas-bag, is it not?

A. It is true that it is always referred to as the balloon. Its functions in so far as it is related to the controlling means and as described, are precisely those of an aeroplane. That is, it is described as having the same tendency to lateral tipping, and carries the same means for controlling the lateral equilibrium. Perhaps the question can best be answered by saying that in so far as it is described as a container of gas, its described functions are those of a balloon, while so far as it has the shape of an aeroplane and

requires control means suited to an aeroplane, its 3469
described functions are those of a purely aeroplane structure.

XQ8. Then if I understand you correctly, the tipping of the balloon is the only characteristic ascribed to it by the specification, which is also a characteristic of an aeroplane, is this correct?

A. The patent itself of course is the best indicator of what it contains, and any such brief statement as the question contains is likely to be misleading. I do not assent to the statement in the question because if the word "balloon" were changed to "aeroplane," no change whatever would be required in the specification, except in 3470
the first sentence of the second paragraph thereof which contains the only reference to the function of the structure as a gas-bag, unless I have overlooked something in the specification. All the rest of the description is exactly such as might and naturally would have been given had the part *a* been only an aeroplane instead of being in fact an aeroplane with a gas-bag on top of it.

XQ9. If the specification refers to any such characteristic other than that mentioned in the foregoing question, will you please quote that portion of the specification mentioning the same?

A. As I stated in my last answer, all of the 3471
specification, except the first sentence of the second paragraph describes the machine precisely as it might and would naturally be described if the word "aeroplane" were substituted for the word "balloon." I do not desire to be understood as in any way modifying the description of the patent, and to make my meaning clear I will say that the function of the part *a* appears to be referred to in the patent only once, and that single reference says merely that it holds gas enough to carry the weight of the entire struc

3472 ture. The structure itself, however, must necessarily act as an aeroplane surface with the general attributes of such a surface, and the patentee has provided it with the controlling means appropriate to such an aeroplane structure. The only thing I can do, therefore, is to refer to all of the specifications other than the part specifically mentioned and explain my meaning in so doing.

XQ10. The end walls of this balloon are shown as vertical. Would these offer any resistance to the lateral movement of the balloon?

A. Yes, as I understand the matter they would
3473 assist in maintaining lateral equilibrium.

XQ11. And this assistance would be the result of resistance offered to the sidewise movement of the balloon, would it not?

A. Yes.

XQ12. Do you find in the specification any suggestion that it is within the contemplation of the patentee that the car should ever move out of a horizontal position?

A. Yes, as I understand the matter the machine is provided with a horizontal rudder for the express purpose of causing the car to point in any desired direction.

3474 XQ13. The movement to which you refer is about a transverse axis. Is any provision made for movement about a longitudinal axis?

A. The car is pivoted on a longitudinal axis, being hung from the supports *e*. It will therefore hang so that its center of gravity is in a vertical plane with this axis. As the operator's weight is shifted from side to side, the car will swing, but the center of gravity of the whole weight will remain in the vertical plane of longitudinal suspension. In other words, the car is so mounted that its central longitudinal plane will make various angles with a true vertical plane, according as the operator leans to one side or the other, and this plane, common to the axis of suspension and the center of weight, will make varying angles with the flat under-surface of the balloon, according to the combined shifting of the operator and tilting of the balloon. 3475

XQ14. Will you please quote any part of the specification which, in your opinion, tends to show that the patentee contemplated the control of the wings *o* by the operator, either by shifting his weight in the car, or otherwise?

A. The fact of course is that it would be impossible with the structure shown and described 3476 to avoid control of the wings *o* by the operator shifting his position, and the whole of the specification which deals with the suspension of the car and its connection with the controlling ailerons would have to be quoted to properly comply with the question.

XQ15. But as a matter of fact the specification makes no reference to control by the operator, does it?

A. Except as the whole description makes it clear that such control could not be avoided, it does not.

XQ16. Will you please quote that portion of 3477 the specification upon which you base your statement that the "rudder is caused to present to the wind that side thereof nearest the side of the aeroplane having the smaller angle of incidence?"

A. I think I have not said quite that. The language referred to is part of the language of Claim 7. All that I have said is that the Schroder machine has "means whereby said rudder is caused to present to the wind that side thereof nearest the side of the aeroplane having the smaller angle of incidence," if that language can be read so as to

3478 apply to the defendants' machine. Personally I do not think that it can be. The language refers to the connecting ropes 15, 19 and 27 of the Wright structure whereby whenever the planes of the Wright machine are warped, the rudder is turned with a view to equalizing the forward resistance to the two sides. The defendants' machine has no such means, but has substantially the same construction as is shown in the Schroder patent, namely, ailerons and a vertical rudder independently controllable. Personally, therefore, I am of the opinion that the language of Claim 7, referred to, does not apply either to the defendants' ma-
3479 chine or to the Schroder machine, and there is no description in the Schroder patent which discloses or implies any such inter-connection between ailerons and vertical rudder. If, however, the language of Claim 7 is to apply to defendants' structure, as I was asked to assume in the question asked me, in my direct examination, and which I was replying to when I made the statement referred to in the question, then that language must equally apply to the Schroder machine since the Schroder machine and the defendants' machine are alike in this respect.

XQ17. Do you find in the Schroder specification
3480 any suggestion that the adjustment of the vertical rear rudder is made with reference to the positions occupied at that time by the wings *o*? If so, please quote that portion of the specification containing the same.

A. Yes, I find it stated that the vertical rudder is to steer with, and if the operation of the ailerons caused the machine to travel in a circle by reason of unequal resistance on the two sides, the operator would of course correct it by using the vertical rudder for its described purpose. I call attention to the fact that in the Wright machine,

according to the description of the Wright patent, 3481
the warping of the wing tips will not preserve
lateral equilibrium unless the vertical rudder is
turned. No such condition exists in the defend-
ants' machine, or in the Schroder machine. The
inter-connection of the ailerons and rudder is not
necessary therefore in a machine having ailerons,
if these normally fly parallel to the air current
through which they pass. The Schroder specifica-
tion does not specifically state, but it does imply,
that in the normal flight of the machine the aile-
rons will not have any effect, that is they will be
parallel to the air stream, and if this is the case,
then it should be noted that there will be no dif- 3482
ference in pressure on the two sides when they are
turned as there is when the wings of the Wright
machine are warped, or if there is any difference,
it would be the reverse of that characterizing the
Wright machine, namely, that the forward resist-
ance is the greatest on the high side, since such
resistance could apparently only be caused by the
construction of the air passage between the aero-
plane surface and the aileron when the rear edge
of the aileron is turned up. I refer to the Schroder
specification and to the entire passage which deals
with the vertical rudder.

XQ18. Then if I understand you correctly, the 3483
vertical rudder in the Schroder device does not co-
operate with the wings, or as you term them, ail-
erons, in maintaining lateral balance, is this true?

A. Only in the sense in which the same is true respecting the ailerons and vertical rudder of the defendants' machine. Personally I do not think it is proper to so describe either the defendants' machine or the Schroder machine.

XQ19. Then you do not find such cooperation either described or implied in the Schroder specification, do you?

3484 A. I find a construction described capable of such coordinated use at the will of the operator, but it is in a structure which, like the defendants' machine, does not require any such use, and in this limited sense I answer the question in the negative.

XQ20. If there is any part of the specification which tends to show that the patentee ever contemplated such use, will you please quote the same?

A. The specification makes it clear that the patentee provided balancing ailerons and a vertical rudder, as well as a horizontal rudder that he put these under the control of the operator, and that
3485 he contemplated their use for any and every set of circumstances which might call for their use. I do not find that the structure is one which would call for such coordinated use in general, and the patentee doubtless understood this, and hence could not have given such a description as is found for instance in the Wright patent, because ailerons properly applied do not give rise to the defects which necessitated the mutual co-relation of wing-warping means and vertical rudder. Since the Schroder machine does not necessitate such co-related use, I do not find in the specification any description thereof other than the description
3486 which shows that the devices were independently controllable and intended to be used whenever they were needed.

XQ21. Are not the horizontal rudder and the vertical rudder rigidly connected so as to have no independent movement?

A. That depends on what is meant by the question. The two rudder surfaces are at right angles to one another. The vertical rudder may therefore be turned to the right or left without in any way altering the angle of the horizontal rudder, and the horizontal rudder may be deflected up or down without in any way altering the plane of the vertical rudder. 3487 The two are thus as completely independent as though they had no connection with one another. Structurally considered, however, they are so mounted as to be maintained in permanent relation to one another, that is they are at right angles to one another and cannot be otherwise.

XQ22. Was the device of the Schroder patent ever built and operated?

A. I don't know.

XQ23. When did you first learn of the existence of the Schroder patent?

A. Only within a few days. 3488

Redirect examination by Mr. Newell.

RDQ24. In other words, if I understand you correctly, the vertical rudder of the Schroder patent is operable by the aviator at any time he pleases and for any purpose he desires. Is that correct?

A. Yes, I understand such to be the disclosure of the Schroder patent, and the mechanism disclosed is suited to such use.

RDQ25. You have stated that the operator could cause the car to swing sidewise, and so operate the ailerons, by shifting his weight sidewise. Please 3489 explain why shifting his weight would cause the car to move sidewise?

A. The car is pivoted at *f, f,* to the lower ends of links *e,* depending from the lower side of the aeroplane frame-work as shown in Figs. 1 and 2. It will necessarily result therefore that the center of weight of the car and operator will hang vertically under the pivotal axis. If the operator leans or moves to one side, he thereby shifts his weight toward that side and the center of weight of car is therefore shifted and the car swings in the opposite

3490 direction so as to bring the center of weight back into the same vertical plane with the axis of support. If the operator moves to the other side, the center of weight of the car is shifted to the other side and the car swings in the opposite direction. Thus the center of weight is kept fixed with relation to the balloon, while the car as a whole is turned with relation thereto, and this necessarily turns the aileron shafts, as has already been described. In other words, the car acts as a pendulum bob and will stand underneath the point of support. By shifting his weight, the operator changes the effective position of the bob and the
3491 car must move through a small angle to bring the weight again under the point of support. As any motion of the car to one side or the other with relation to the aeroplane surface necessarily acts through the arms f', links q and levers o'' to move the ailerons, it follows that the shifting of the operator's weight acts to produce such turning of the ailerons.

(Signed) FRANK N. WATERMAN.

Deposition Closed.

3492

Magistrate's Certificate. 3493

UNITED STATES DISTRICT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY *v.* THE HERRING-CURTISS COMPANY and GLENN H. CURTISS...	In Equity. #400.

I, Beatrice Mirvis, a Notary Public in and for the County of New York, do hereby certify that pursuant to notice issued and served in the above-mentioned cause, I was attended at the office of Emerson R. Newell, #2 Rector Street, New York City, N. Y., by said Newell, counsel for defendants, and also Edward L. Reed, Esq., counsel for complainant, on the 30th day of September, 1912, as stated in said testimony; that the witnesses named therein, Albert Stetson and Frank N. Waterman, who were of sound mind and lawful age, were witnesses who had been previously called and sworn in this cause, and they thereupon testified as above shown; 3495
that the depositions by them subscribed as above set forth were by me reduced to writing in the presence of the witnesses themselves and from their statements, and were then subscribed by the said witnesses in my presence; and that all was so done, written and signed in the presence of said counsel. I further certify that the reason for taking said depositions was and is, and the fact was and is, that all of the deponents live more than 100 miles from the place where

3496 said Court was sitting and said suit is appointed by law to be tried; that I am neither of counsel nor attorney to either of the parties to said suit, nor interested in the event of said case; and that it being impracticable for me to deliver said depositions with my own hand into the Court for which they were taken, I have retained the same for the purpose of being sealed up and directed with my own hand and speedily and safely transmitted to the said Court for which it was taken. I further certify that my fees for taking said testimony amounted to $10, and that said amount has been paid by defendants.

3497 Witness my hand and seal at New York City, New York, this 7th day of October, 1912.

BEATRICE MIRVIS,
[NOTARY SEAL.] Notary Public, #160,
New York Co.

3498

Defendant's Exhibit, Translation of Schroder Patent. 3499

Imperial Patent Office.

Patent No. 77036. Issued Oct. 4, 1894.

Class 77. Sport.

Gottfried Schroeder, of Unter-Bredow near Stettin.

Airship with Device for maintaining the Wedge-shaped Balloon in Horizontal Position.

Patented in the German Empire on and after November 11, 1893.

The subject matter of the present invention relates to an airship with a device for holding the wedge-shaped balloon in horizontal position. Figure 1 shows the airship seen obliquely from the rear and below; Figure 2 a view obliquely from the rear upward with the omission of the balloon *a*. *a* is a horizontal wedge-shaped balloon beneath which, at its center of gravity hangs the car *b* with a long point forwards, which car on its part, is fastened by the link pieces *f* and *e*, in such a manner that it can swing like a pendulum to right and left. 3500

The balloon *a* holds so much gas that the entire airship with its contents is carried thereby. The 3501 forward movement of the airship is effected by means of blades *d*, which act like the screw of a ship. They are located at the rear end, at both sides of the car *b*, Figure 1 and 2, and are located on the blade rods *d'*. Figures 1, 2 and 3, which, also are firmly connected with the shaft *d''* rotating in the bearings g. The blades *d* are turnable about their rod *d'*, and are so held by the spring *h* that when at rest they stand parallel with the shaft *d''* (Figures 3 and 5). Figure 5 shows the blade, seen in the direction of the blade rod *d'*.

3502 If the airship is to be moved forward the shaft d'' is so rotated by an engine located within the car that the blades rotate in the direction shown by the arrows in Figures 1 and 2. In this rotation the blades describe circles. Figure 4 shows two positions of the blades from the rear, seen in the direction of the shaft d''. If the blades rotate (Figure 4) in the direction of the outer arrows, there arises an air current against the same which meets them in a direction tangential to the circle, as the inner arrows show. By this air current the blades, since they are turnable about their rod, would be pressed backward like a flag,
3503 if they were not held by the spring *h*. The spring *h* allows the blade to give only so far backward (Position I in Figure 4), that it stands obliquely to the shaft d''. It is then met obliquely by the air current, and the pressure produced by the air current is so divided that, a portion of the same acts in the direction of the shaft d'' Figure 6, in which the blade seen in the direction of its axle, shows a position of the same oblique to the shaft d''. The blade through the air current meeting it in the direction of the arrow I, is brought from its position of rest (Figure 5) into the position of Figure 6. The air current then
3504 meets the blade obliquely, and the pressure against the same caused by it divides itself in such a manner that one portion of the same acts in the direction of the arrow II, the other, in the direction of the arrow III, consequently in the direction of the shaft d''. The pressure in the direction of the arrow III is the one that moves the airship forward in the direction of the shaft d'', while the pressure in the direction of the arrow II must be overcome by the engine. If, now, the airship is moved by the air in the direction of the shaft d'', there arises thereby an air

current from ahead against the same in the direc- 3505
tion of the shaft d''. Thereby, however, the direction of the air current against the blade is changed, for it is the resultant of the two directions, namely, of the air current from ahead in the direction of the shaft d'' and of the tangential direction to the circle, which the blades describe in their rotation, and it is different according to the speed ratio of the two air currents. If the speed of travel is equal to the speed of rotation, that is, if the travelling vehicle moves one metre through the air in the same time in which the blades move one metre—in Figure 6
the course AB is equal to the course BC, trav- 3506
ersed by the blades—then the air current meets the blade in the direction of the diagonal of the parallelogram formed from AB and BC, consequently, in the direction of the arrow IV. The blade would then be without action. If the speed of travel is double as great as the speed of rotation—in Figure 6, EB=2BC—, then the air current meets the blade in the direction of the arrow V. If the speed of travel is only half as great as the speed of revolution—in Figure 6 AB=½ BD—then the air current meets the blade in the direction of the arrow II. Only in this case
would the blade be hit by the air current on its 3507
outer face and be able to act. By the spring *h*, the blade, as soon as there is no pressure against it, is pressed forward against this pressure of the spring until it is continuously hit by the air current on the forward side, and, consequently can continuously act. The spring *h* is so arranged that it, if the blade stands still, exerts only a very gentle pressure against the same, its pressure is, however, so much the more increased the farther the blade is turned backward.

3508 In order to be able to change at will the direction of motion of the airship, there is attached at the rear end of the balloon (Figure 1) a double rudder, which consists of a horizontal surface c and a vertical surface c'. In the two bearings k fastened to the balloon turns the vertical shaft *1*, on which and below is located the cross-piece $1'$ with the two bearings l''. In these bearings rotates the horizontal shaft m, on which is fastened the double rudder. The rudder can turn on the vertical shaft *1* to the right and left, on the horizontal shaft m upwards and downwards. At the ends of the shaft m are fastened the upright
3509 standing levers m'. and in the centre is fastened the downwardly directed lever m''. Within the car (Figure 2 shows the car from above and open on the left side) there is attached a device, which consists of the same pieces, as the connection of the rudder with the balloon, namely, of the vertical shaft *1*, which turns in the bearings k, with the cross-piece $1'$ and the two bearings $1''$, of the horizontal shaft m with the two upright standing levers m' and the downwardly directed lever m''. Moreover, there is located on the shaft m also the backwardly directed lever c. The two levers m'' of the car are
3510 connected with the two levers m'' of the rudder by means of the two ropes n, and lever m'' of the car is connected with the lever m'' of the rudder by the rope n'. The two ropes n run over the wheels n'', Figure 2.

If the airship has begun the trip, and if its direction of motion is to be changed, to be directed more upwardly, the lever c within the car (Figure 2) is lifted. Thereby the two levers m' of the car are rotated forwards, the ropes n tightened, whereby also the two levers m' of the rudder are rotated forwards. Since, however, these

are connected with the shaft *m* and by these with 3511
the rudder, the rudder is turned upwardly. In this position the horizontal rudder is struck obliquely on the upper side by the air current coming from the front, whereby a pressure downwardly is exerted upon the same. The airship at its rear part is, therefore, pressed downward, the shaft *d''* is thereby directed upwards at the front, and in this direction the airship is then moved forward.

If the movement of the airship is to be directed downwards, the lever *c* of the car is pressed downward, thereby the lever *m''* of the car is rotated forward, the rope *n'* tightened, whereby the lever *m''* 3512
of the rudder is turned forward and the rudder downward. In this position the under side of the horizontal rudder is then hit obliquely by the air current coming from the front, whereby a pressure is exerted upwards against the rudder. Thereby, the airship is raised at its rear portion, the shaft *d''* is directed downward at the front and the ship is moved in this direction. If the airship is to swing to the left, the lever *c* of the car is rotated to the left: thereby, the left rope *n* is tightened, because, by the left turning of the lever *c* the shaft *m* with its left end and the left lever *m'* fastened to it are pushed forward. The shaft 3513
m of the rudder and with it the rudder itself fastened thereto make the same movement, because by the rope the left lever *m'* of the rudder is drawn forward. In this position the air current coming from the front meets the left side of the vertical rudder; thereby a pressure is exerted to the right against the same. The airship is turned at its rear portion to the right, the shaft *d''*, consequently, is turned to the left, and the airship advances in this direction. Turning the airship to the right is effected by turning the lever *c* of the car to the right.

3514 In order to hold the balloon constantly horizontal in the lateral direction, the wings o are attached beneath the balloon to both sides of the car. These with their shafts o' turn in the bearings p fastened to the balloon. The shafts o' have each a lever o'' directed forwards, which are connected with the levers f' of the forward link piece f by the connecting pieces q (Figures 1 and 2). Should, perhaps, the right side of the balloon be inclined downward, then the right wing o connected with it and its lever are also carried downward. Since the car, however, does not follow this dip, the two levers f' also do not follow this
3515 dip. The end of the right lever o'' would have to separate from the pivot of the right lever f'. This, however, cannot happen, because the two are connected. The end of the right lever o'' must, consequently remain at the same height, while the wing goes downward with the balloon. Thereby, the right wing o so adjusts itself that the air current coming from the front hits the under side obliquely, whereby, a pressure upward is exerted. The left wing o will assume the opposite position, for, since, on the dipping of the balloon to the right, its left side, and with it the left wing o is raised, then the end of the left lever o'' would
3516 have to approach the pivot of the left lever f'. Since, however, this cannot happen, because they are both connected, the left wing o'' will so adjust itself that the air current coming from the front meets its upper side obliquely, whereby a pressure is exerted downwardly. The balloon is, therefore, on the right pressed upward, on the left downward. As soon as it returns to the horizontal position, the wings again set themselves straight. If the balloon should dip to the left, then the wings would exert the opposite action. The wings have, therefore, the purpose of holding the balloon in equilibrium.

Patent Claim: 3517

Airship with wedge-shaped balloon, which latter (a) is held in horizontal position thereby, that two surfaces (*oo*) adjustable as regards the horizon, arranged at the side of the car (b) on the balloon, on lateral dipping of the balloon, are adjusted in opposite directions by means of rods *f′ q o′* by the car (b) which hangs always ver-
longitudinal axis of the balloon, so that the wind
pressure on these surfaces tends to rotate the
tically downwards, on two pivots paralled to the
balloon in one and the same direction.

3518

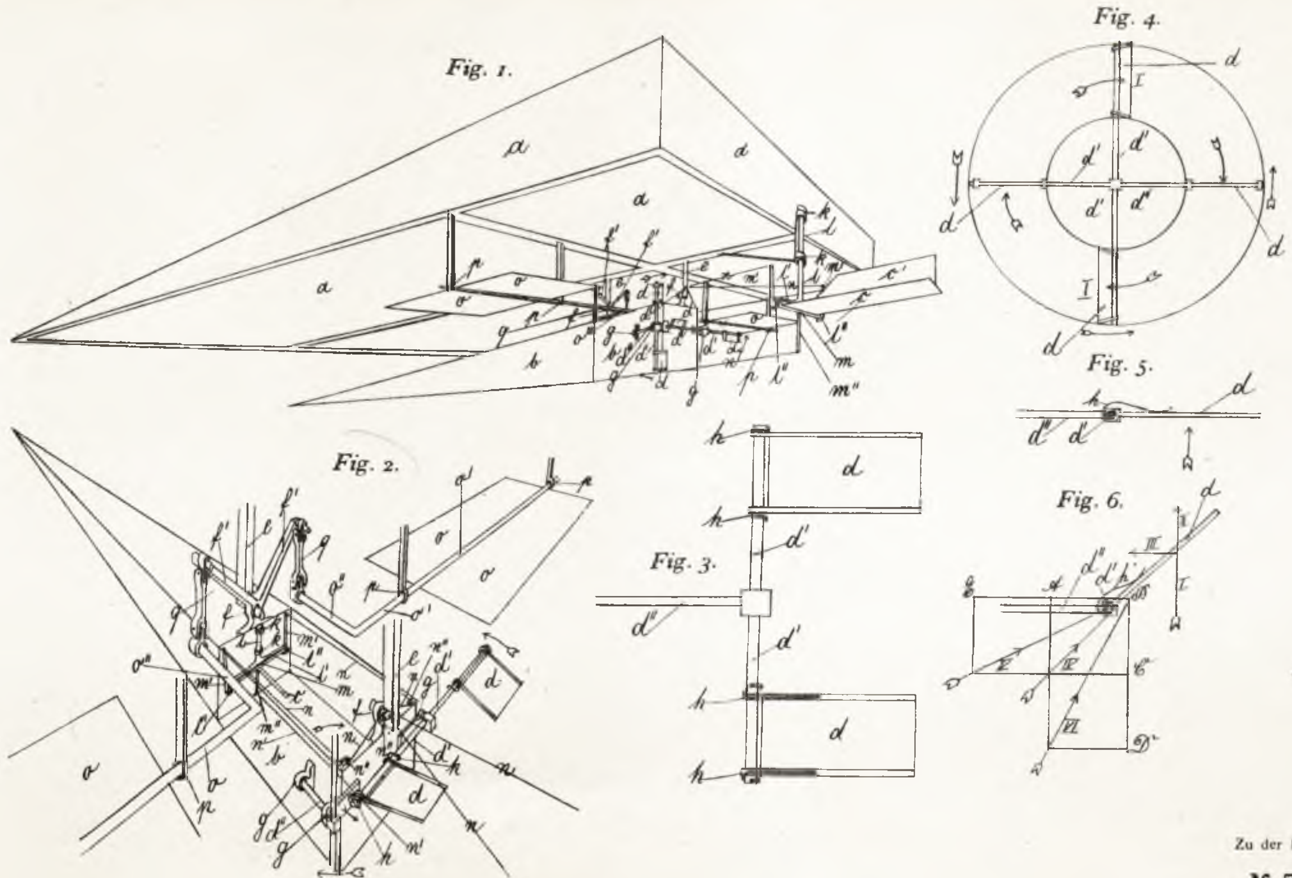
[1584]

3519

– Gas tank supports –
– No aeroplane – Mach. would not travel at incidence.
– Def. treated bottom tank as aeroplane – May have looked like one to him –
– Flaps turn wrong way when mach. blown sidewise. Use model –

GOTTFRIED SCHRÖDER in UNTER-BREDOW bei STETTIN.

Luftschiff mit Vorrichtung, um den keilförmigen Ballon in waagerechter Lage zu erhalten.



Zu der Patentschrift

№ 77036.

PHOTOGR. DRUCK DER REICHSDRUCKEREI.

KAISERLICHES PATENTAMT.

AUSGEGEBEN DEN 4. OCTOBER 1894.

PATENTSCHRIFT

— № 77036 —

KLASSE 77: Sport.

GOTTFRIED SCHRÖDER in UNTER-BREDOW bei STETTIN.

Luftschiff mit Vorrichtung, um den keilförmigen Ballon in waagerechter Lage zu erhalten.

Patentirt im Deutschen Reiche vom 11. November 1893 ab.

Gegenstand vorliegender Erfindung betrifft ein Luftschiff mit einer Vorrichtung, um den keilförmigen Ballon in waagerechter Lage zu halten. Fig. 1 zeigt das Luftschiff schräg von hinten und unten gesehen, Fig. 2 eine Ansicht schräg von hinten, oben mit Weglassung des Ballons *a*. *a* ist ein liegender keilförmiger Ballon, unter welchem in seinem Schwerpunkt die nach vorn lang zugespitzte Gondel *b* hängt, die ihrerseits durch die Gelenkstücke *f* und *e* so befestigt ist, dafs sie sich pendelartig nach rechts und links bewegen läfst.

Der Ballon *a* enthält so viel Gas, dafs das ganze Luftschiff mit seinem Inhalt dadurch getragen wird. Die Fortbewegung des Luftschiffes wird durch Schaufeln *d* bewirkt, die wie die Schraube eines Schiffes wirken; sie befinden sich am hinteren Ende zu beiden Seiten der Gondel *b*, Fig. 1 und 2, und sitzen an den Schaufelstielen *d'*, Fig. 1, 2 und 3, welche wieder mit der sich in den Lagern *g* drehenden Welle *d''* fest verbunden sind. Die Schaufeln *d* sind um ihre Stiele *d'* drehbar und werden von der Feder *h* so gehalten, dafs sie in der Ruhe parallel mit der Welle *d''* stehen (Fig. 3 und 5). Fig. 5 zeigt die Schaufel in der Richtung des Schaufelstieles *d'* gesehen.

Soll das Luftschiff fortbewegt werden, so wird die Welle *d''* von einer Maschine, welche sich innerhalb der Gondel befindet, so gedreht, dafs die Schaufeln sich in der Richtung drehen, wie die Pfeile in Fig. 1 und 2 zeigen. Bei dieser Drehung beschreiben die Schaufeln Kreise. Fig. 4 zeigt zwei Stellungen der Schaufeln von hinten, in der Richtung der Welle *d''* gesehen. Drehen sich die Schaufeln (Fig. 4) in der Richtung der äufseren Pfeile, so entsteht ein Luftstrom gegen dieselben, der sie in der tangentialen Richtung der Kreise trifft, wie die inneren Pfeile zeigen. Von diesem Luftstrom würden die Schaufeln, weil sie um ihre Stiele drehbar sind, wie eine Fahne zurückgedrückt werden, wenn sie nicht von der Feder *h* gehalten würden. Die Feder *h* läfst die Schaufel nur so weit zurückgehen (Stellung I in Fig. 4), dafs sie schräg zur Welle *d''* steht. Sie wird von dem Luftstrom dann schräg getroffen, und der von dem Luftstrom erzeugte Druck vertheilt sich so, dafs ein Theil desselben in der Richtung der Welle *d''* wirkt. Fig. 6, in welcher die Schaufel in der Richtung ihres Stieles gesehen wird, zeigt eine schräge Stellung derselben zur Welle *d''*. Die Schaufel wird durch den in der Richtung des Pfeiles I sie treffenden Luftstrom aus ihrer Ruhestellung (Fig. 5) in die Stellung von Fig. 6 gebracht. Der Luftstrom trifft alsdann die Schaufel schräg, und der von ihm verursachte Druck gegen dieselbe vertheilt sich so, dafs ein Theil desselben in der Richtung des Pfeiles II, der andere in der Richtung des Pfeiles III, also in der Richtung der Welle *d''*, wirkt. Der Druck in der Richtung des Pfeiles III ist derjenige, welcher das Luftschiff in der Richtung der Welle *d''* fortbewegt, während der Druck in der Richtung des Pfeiles II von der Maschine überwunden werden mufs. Wird nun das Luftschiff in der Richtung der Welle d'' durch die Luft fortbewegt, so entsteht dadurch ein Luftstrom von vorn gegen dasselbe in der Richtung der Welle d''. Dadurch wird aber die Richtung des Luftstromes gegen die Schaufel verändert, denn dieselbe resultirt aus den beiden Richtungen, nämlich aus der des Luftstromes von vorn in der Richtung der Welle d'' und der tangentialen Richtung der Kreise, welche die Schaufeln bei ihrer Umdrehung beschreiben, und ist je nach dem Geschwindigkeitsverhältnifs der beiden Luftströme verschieden. Ist die Fahrgeschwindigkeit gleich der Drehungsgeschwindigkeit, d. h. bewegt sich das Fahrzeug in derselben Zeit 1 m durch die Luft, in welcher sich die Schaufeln 1 m bewegen — in Fig. 6 ist Fahrstrecke AB gleich der von den Schaufeln durchlaufenen Strecke BC —, so trifft der Luftstrom die Schaufel in der Richtung der Diagonale des aus AB und BC gebildeten Parallelogramms, also in der Richtung des Pfeiles IV. Die Schaufel wäre alsdann wirkungslos. Ist die Fahrgeschwindigkeit doppelt so grofs als die Drehungsgeschwindigkeit — in Fig. 6 $EB = 2\,BC$ —, so trifft der Luftstrom die Schaufel in der Richtung des Pfeiles V. Ist die Fahrgeschwindigkeit nur halb so grofs als die Drehungsgeschwindigkeit — in Fig. 6 $AB = \frac{1}{2}\,BD$ —, so trifft der Luftstrom die Schaufel in der Richtung des Pfeiles II. Nur in diesem Falle würde die Schaufel von dem Luftstrom an der vorderen Seite getroffen werden und wirken können. Durch die Feder h wird die Schaufel, sobald kein Druck gegen dieselbe, dem Druck der Feder entgegen, vorhanden ist, so weit vorgedrückt, dafs sie stets von dem Luftstrom an der vorderen Seite getroffen wird und somit stets wirken kann. Die Feder h wird so eingerichtet, dafs sie, wenn die Schaufel stillsteht, nur einen ganz gelinden Druck gegen dieselbe ausübt, ihr Druck sich aber um so mehr vergröfsert, je weiter die Schaufel zurückgedreht wird.

Um die Fortbewegungsrichtung des Luftschiffes beliebig verändern zu können, ist am hinteren Ende des Ballons (Fig. 1) ein Doppelsteuer angebracht, welches aus einer waagerechten Fläche c und einer senkrechten Fläche c' besteht. In den beiden am Ballon befestigten Lagern k dreht sich die senkrechte Welle l, an welcher sich unten das Querstück l' mit den beiden Lagern l'' befindet. In diesen Lagern dreht sich die waagerechte Welle m, an welcher das Doppelsteuer befestigt ist. An der senkrechten Welle l läfst sich das Steuer nach rechts und links drehen, an der waagerechten Welle m aufwärts und abwärts. An den Enden der Welle m sind die beiden aufrecht stehenden Hebel m' und in der Mitte ist der abwärts gerichtete Hebel m'' befestigt. Innerhalb der Gondel (Fig. 2 zeigt die Gondel oben und an der linken Seite offen) ist eine Vorrichtung angebracht, welche aus denselben Stücken besteht wie die Verbindung des Steuers mit dem Ballon, nämlich aus der senkrechten Welle i, welche sich in den Lagern k dreht, mit dem Querstück l' und den beiden Lagern l'', der waagerechten Welle m mit den beiden aufrecht stehenden Hebeln m' und dem abwärts gerichteten Hebel m''. Aufserdem befindet sich an der Welle m noch der rückwärts gerichtete Hebel c. Die beiden Hebel m' der Gondel sind mit den beiden Hebeln m'' des Steuers durch die beiden Schnüre n, der Hebel m'' der Gondel ist mit dem Hebel m'' des Steuers durch die Schnur n' verbunden. Die beiden Schnüre n laufen um die Rollen n'', Fig. 2.

Ist das Luftschiff in der Fahrt begriffen und soll seine Bewegungsrichtung verändert, etwa mehr nach oben gerichtet werden, so wird der Hebel c innerhalb der Gondel (Fig. 2) gehoben. Dadurch werden die beiden Hebel m' der Gondel nach vorn gedreht, die Schnüre n angezogen, wodurch auch die beiden Hebel m' des Steuers nach vorn gedreht werden. Da diese aber mit der Welle m und durch diese mit dem Steuer verbunden sind, so wird das Steuer nach oben gedreht. In dieser Stellung wird das waagerechte Steuer von dem von vorn kommenden Luftstrom an der oberen Seite schräg getroffen, wodurch auf dasselbe ein Druck nach unten bewirkt wird. Es wird somit das Luftschiff in seinem hinteren Theil nach unten gedrückt, die Welle d'' wird dadurch vorn aufwärts gerichtet, und in dieser Richtung wird sich alsdann das Luftschiff fortbewegen.

Soll die Bewegung des Luftschiffes nach abwärts gerichtet werden, so wird der Hebel c der Gondel nach unten gedrückt, dadurch wird der Hebel m'' der Gondel nach vorn gedreht, die Schnur n' angezogen, wodurch der Hebel m'' des Steuers nach vorn und das Steuer abwärts gedreht wird. In dieser Stellung wird dann die untere Seite des waagerechten Steuers von dem von vorn kommenden Luftstrom schräg getroffen, wodurch ein Druck nach aufwärts gegen das Steuer bewirkt wird. Dadurch wird das Luftschiff in seinem hinteren Theil gehoben, die Welle d'' vorn abwärts gerichtet und das Schiff in dieser Richtung fortbewegt. Soll das Luftschiff nach links schwenken, so wird der Hebel c der Gondel nach links gedreht; dadurch wird die linke Schnur n angezogen, weil durch die Linksdrehung des Hebels c die Welle m mit dem linken Ende und der an ihr befestigte linke Hebel m' nach vorn geschoben. Dieselbe Bewegung macht auch die Welle m des Steuers und mit ihr das an ihr befestigte Steuer selbst, weil durch die Schnur der linke Hebel m'

des Steuers nach vorn gezogen wird. In dieser Stellung trifft der von vorn kommende Luftstrom die linke Seite des senkrechten Steuers; dadurch wird ein Druck gegen dasselbe nach rechts bewirkt. Es wird das Luftschiff in seinem hinteren Theil nach rechts, die Welle *d''* somit vorn nach links gedreht und in dieser Richtung das Luftschiff fortbewegt. Die Rechtsschwenkung des Luftschiffes wird durch eine Rechtsdrehung des Hebels *c* der Gondel bewirkt.

Um den Ballon in seitlicher Richtung stets waagerecht zu halten, sind unterhalb des Ballons zu beiden Seiten der Gondel die Flügel *o* angebracht. Dieselben drehen sich mit ihren Wellen *o'* in den am Ballon befestigten Lagern *p*. Die Wellen *o'* haben jede einen nach vorn gerichteten Hebel *o''*, welche mit den Hebeln *f'* des vorderen Gelenkstückes *f* durch die Verbindungsstücke *q* verbunden sind (Fig. 1 und 2). Würde sich etwa die rechte Seite des Ballons abwärts neigen, so würde auch der mit ihm verbundene rechte Flügel *o* und dessen Hebel *o''* abwärts gedrückt werden. Da die Gondel aber diese Neigung nicht mitmacht, so machen auch die beiden Hebel *f'* diese Neigung nicht mit. Das Ende des rechten Hebels *o''* würde sich von dem Zapfen des rechten Hebels *f'* entfernen müssen. Dies kann aber nicht geschehen, weil sie beide verbunden sind. Das Ende des rechten Hebels *o''* mufs also in derselben Höhe bleiben, während der Flügel mit dem Ballon abwärts geht. Dadurch stellt sich der rechte Flügel *o* so ein, dafs der von vorn kommende Luftstrom die untere Seite schräg trifft, wodurch ein Druck nach oben bewirkt wird. Der linke Flügel *o* wird die entgegengesetzte Stellung einnehmen, denn da bei der Neigung des Ballons nach rechts seine linke Seite und mit ihm der linke Flügel *o* gehoben wird, so müfste das Ende des linken Hebels *o''* dem Zapfen des linken Hebels f^1 sich nähern. Da dies aber nicht geschehen kann, weil sie beide verbunden sind, so wird der linke Flügel *o''* sich so einstellen, dafs der von vorn kommende Luftstrom seine obere Seite schräg trifft, wodurch ein Druck nach unten bewirkt wird. Der Ballon wird somit rechts nach oben, links nach unten gedrückt. Sobald er in die waagerechte Stellung zurückkehrt, stellen sich auch die Flügel wieder gerade. Würde sich der Ballon nach links neigen, so würden die Flügel die entgegengesetzte Wirkung ausüben. Die Flügel haben somit den Zweck, den Ballon im Gleichgewicht zu halten.

Patent-Anspruch:

Luftschiff mit keilförmigem Ballon, welch letzterer *(a)* dadurch in waagerechter Lage erhalten wird, dafs zwei seitlich der Gondel *(b)* am Ballon angeordnete, gegen den Horizont verstellbare Flächen *(o o)* bei seitlicher Neigung des Ballons durch die Gondel *(b)*, welche an zwei zur Längsachse des Ballons parallelen Zapfen immer vertical nach unten hängt, mittelst Gestänges *f' q o''* nach entgegengesetzter Richtung eingestellt werden, so dafs der Winddruck auf diese Flächen den Ballon in ein und demselben Sinne zu drehen bestrebt ist.

Hierzu 1 Blatt Zeichnungen.

BERLIN. GEDRUCKT IN DER REICHSDRUCKEREI

DISTRICT COURT OF THE UNITED STATES,

WESTERN DISTRICT OF NEW YORK.

In Equity No. 400.

THE WRIGHT COMPANY,
Complainant,

AGAINST

THE HERRING-CURTISS COMPANY and GLENN H. CURTISS,
Defendants.

H. A. TOULMIN (FREDERICK P. FISH and EDMUND WETMORE, of Counsel), for Complainant.

EMERSON R. NEWELL (J. EDGAR BULL, of Counsel), for Defendants.

HAZEL, *J.*:

This bill in equity relates to the infringement of United States letters patent granted May 22, 1906, to Orville and Wilbur Wright on application for patent filed March 23, 1903, for improvements in flying machines, or, in other words, for a structure commonly known as an aeroplane. At this date, owing to articles in daily papers and periodicals with regard to notable flights in this country and abroad by the late Wilbur Wright, Orville Wright, defendant Glenn H. Curtiss, and other venturesome aviators, the aeroplane and the *modus operandi* thereof are reasonably familiar to the intelligent public. That such structures are supported in their flight by the reaction of the air against an inclined surface, and that the advancing air presses against the plane surfaces thereby inclining them to rise, while at the same time a resistance to forward motion is encountered which is overcome by the propelling motor, are facts now reasonably familiar to us.

By those who early studied the art the fundamental physical principles involved in the flight of a plane heavier than air when advancing against the wind or currents of air were well recognized. That a plane descending in response to the force of gravity naturally inclined in a forward direction, and that the air resisted its forward descent in proportion to the exposed surface of the plane, were matters thoroughly understood by those who were interested in the subject. This knowledge eventuated in the structures for aerial flying shown in the exhibit publications and in the Wright patent in suit. The objects of the latter, according to the specification, are:

> "To provide means for maintaining or restoring the equilibrium or lateral balance of the apparatus, to provide means for guiding the machine both vertically and horizontally, and to provide a structure combining lightness, strength, convenience of construction, and certain other advantages which will hereinafter appear."

There are eighteen claims in the patent, but claims 3, 7, 14, and 15 only are infringed, and they read as follows:

> "3. In a flying-machine, a normally flat aeroplane having lateral marginal portions

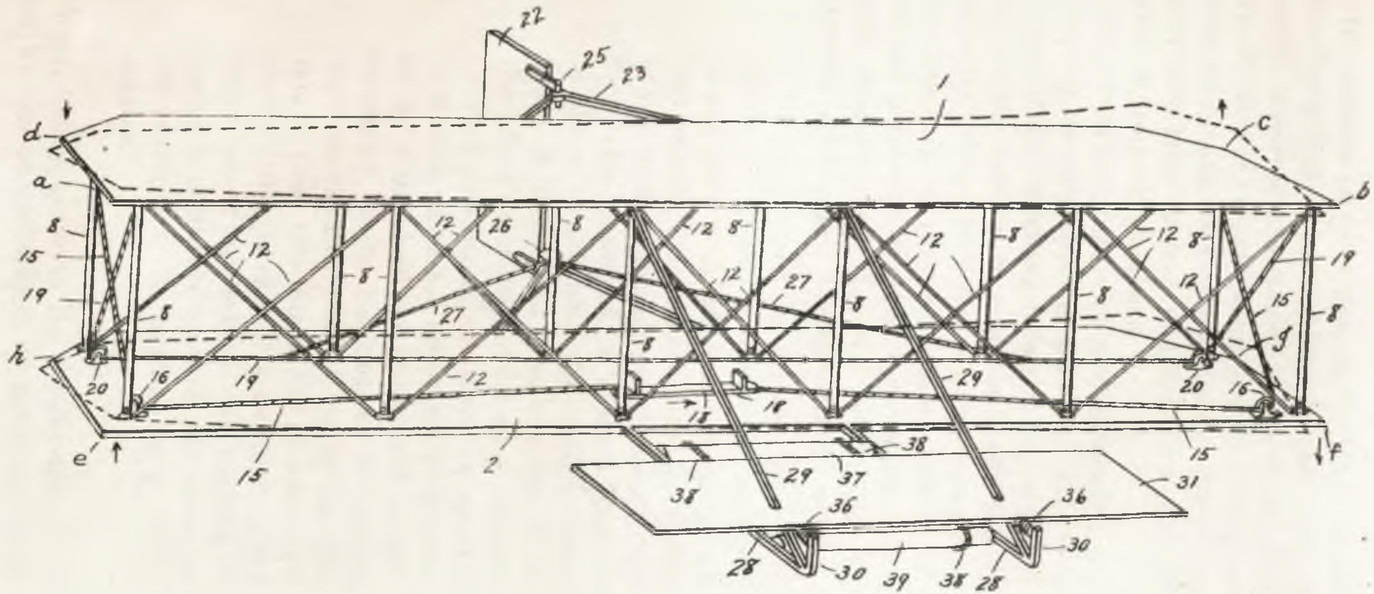
capable of movement to different positions above or below the normal plane of the body of the aeroplane, such movement being about an axis transverse to the line of flight, whereby said lateral marginal portions may be moved to different angles relatively to the normal plane of the body of the aeroplane, and also to different angles relatively to each other, so as to present to the atmosphere different angles of incidence, and means for simultaneously imparting such movement to said lateral marginal portions, substantially as described."

"7. In a flying-machine, the combination with an aeroplane, and means for simultaneously moving the lateral portions thereof into different angular relations to the normal plane of the body of the aeroplane and to each other, so as to present to the atmosphere different angles of incidence, of a vertical rudder, and means whereby said rudder is caused to present to the wind that side thereof nearest the side of the aeroplane having the smaller angle of incidence and offering the least resistance to the atmosphere, substantially as described."

"14. A flying-machine comprising superposed connected aeroplanes, means for moving the opposite lateral portions of said aeroplane to different angles to the normal planes thereof, a vertical rudder, means for moving said vertical rudder toward that side of the machine presenting the smaller angle of incidence and the least resistance to the atmosphere, and a horizontal rudder provided with means for presenting its upper or under surface to the resistance of the atmosphere, substantially as described."

"15. A flying-machine comprising superposed connected aeroplanes, means for moving the opposite lateral portions of said aeroplanes to different angles to the normal planes thereof, a vertical rudder, means for moving said vertical rudder toward that side of the machine presenting the smaller angle of incidence and the least resistance to the atmosphere, and a horizontal rudder provided with means for presenting its upper or under surface to the resistance of the atmosphere, said vertical rudder being located at the rear of the machine and said horizontal rudder at the front of the machine, substantially as described."

The following is a perspective view of the Wright machine.



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The defenses are: (1) That the patent is not entitled to a broad construction, (2) that if it is broadly construed it is invalid in view of the prior art, (3) that if properly construed as to its scope the defendants do not infringe, and (4) that in any event defendants' mode of flying is on a different principle from complainant's.

The record is replete with publications and oral testimony showing that the principal obstacle to the use of the aeroplane before the invention in suit was the inability to maintain lateral balance, due to disturbing aerial forces which swerved the aeroplane from its intended course. Indeed, this was the perplexing problem upon which human flight depended and the one with which the patentees had to cope. The specification says:

> "In flying-machines of the character to which this invention relates the apparatus is supported in the air by reason of the contact between the air and the under surface of one or more aëroplanes, the contact-surface being presented at a small angle of incidence to the air. The relative movements of the air and aeroplane may be derived from the motion of the air in the form of wind blowing in the direction opposite to that in which the apparatus is traveling or by a combined downward and forward movement of the machine, as in starting from an elevated position or by combination of these two things, and in either case the operation is that of a soaring-machine, while power applied to the machine to propel it positively forward will cause the air to support the machine in a similar manner."

Much, indeed, prior to the Wright patent had been written on the subject of aerial machinery by Prof. Langley of the Smithsonian Institute, Octave Chanute, and others, and there were a number of patents in this country and in foreign countries disclosing diligent and painstaking efforts by inventors to achieve success in aerial navigation with heavier-than-air machines, but all such efforts for one reason or another were abortive, and the intentions of the inventors and experimentors miscarried. The prior art taught that Langley, Lilienthal, Chanute, Maxim, and others had faithfully endeavored to solve the difficulties and remedy the imperfections in apparatus. Flying-machines of various kinds had previously been built, but no one had flown save a few, Chanute in this country, and Lilienthal and Pilcher abroad, who were engaged in experimentation.

In this situation the patentees conceived the idea of hinging dihedral planes to supports at their front and rear margins with flexible joints to permit warping or tilting them at their extreme lateral ends by the use of suitable levers to impart to the aeroplane surface a helicoidal twist. On this point the specification says:

> "We prefer this construction and mode of operation for the reason that it gives a gradually-increasing angle to the body of each aeroplane from the central longitudinal line thereof outward to the margin, thus giving a continuous surface on each side of the machine, which has a gradually increasing or decreasing angle of incidence from the center of the machine to either side. We wish it to be understood, however, that our invention is not limited to this particular construction, since any construction whereby the angular relations of the lateral margins of the aeroplanes may be varied in opposite directions with respect to the nor-

mal planes of said aeroplanes comes within the scope of our invention."

It was believed in the beginning that by warping or depressing the margins of the supporting planes at opposite ends, the aeroplane could be controlled in its movements and its equilbrium maintained in flying, and the proofs show that in their earlier efforts the inventors did not design to use either a horizontal rudder in front of the machine or a vertical rudder at the rear, but later, before the application for patent was filed, these instrumentalities were added. The movable verticle rudder or tail exerts a retarding influence on the side of the machine which in flying has a tendency to move ahead of the opposite side, and thus assists the wings or marginal ends in keeping the aeroplane properly balanced.

Means were provided for increasing or decreasing the angle of incidence to restore lateral balance, such means consisting of a rope attached both to the vertical rudder and to the wings or margins which enabled the aviator lying in the cradle to operate by the motion of his body, both instrumentalities for maintaining the equilibrium of the apparatus. In the estimation of the Wright brothers the machine was prevented from turning on its vertical axis by the adaptation of the movable vertical rudder as an auxiliary to the warping planes or ailerons as described in the specification, and by the conjoint use of such parts they were able to fly, steering in either direction, and to restore and retain equilibrium.

To induce a construction of the claims in controversy that will exclude defendants' aeroplanes it is contended that the patentees merely improved the known gliding-machine,—a contrivance for gliding down slopes—and that the wing tips, horizontal rudder, and vertical rudder were old separately and in combination. In the year 1896, and previously, Lilienthal had flown experimentally with a gliding machine which was afterwards wrecked. Later, the Pilcher and Chanute structures, of both the monoplane and biplane type, were used for experimental flying, but they also were failures, and little success was achieved in correcting their imperfections.

In a published address by Chanute who had carefully studied the subject of aero-dynamics and disclosed a keen familiarity with flying machines of the aeroplane type, there is contained a percursory review of the aeroplane and its practicability up to the year 1897. In this address he points out the differences between curved and flat planes with regard to the effect of air pressure thereon, but his descriptions were not sufficiently definite to suggest the later improvements by the patentees. He declared that the use of a horse-power motor to facilitate flight, if of sufficiently light weight, was a minor detail and not a serious problem, and that the maintenance of the equilibrium was the most important problem in connection with aerial navigation. While his experimentation and publications were helpful to the patentees, it is not contended by the defendants that they were anticipatory of the claims in suit, but merely that they showed the progress that had been made in efforts to make possible human flight. That the prior patents do not show the patented combination of complainant's construction is evident from an examination thereof.

The Henson British patent of 1842 was for a monoplane having two pivoted tails independently operated, one a horizontal tail controlling the upward and downward movements of the apparatus, the other a vertical tail guiding its direction. The statement in the specification as to the dimensions of the machine indicates its impracticability, and there is nothing to show that the patentee had in mind the principle that the steering or control of the machine depended upon the tilt of the wings in connection with the use of the vertical rudder.

In the Maxim British patent, No. 16,883, of 1889, for an aerial machine, there is a vertical movable rudder and a horizontal rudder, the former for guiding the aeroplane in an upward or downward direction, and the latter for steering to right or left. While the function of the Maxim horizontal rudder was apparently the same as that of the Wright horizontal rudder, the function of the vertical rudder was essentially different.

In the Lanchester British patent No. 3608, the intention of the patentee was to secure the lateral balance of his aerial machine by automatic means. He however never succeeded in carrying out his design. In addition to the horizontal rudder his machine carried a rear rudder which was used for steering and not for maintaining the equilibrium of the contrivance, and the wings were immovable

The patents to Crepar and Johnston for gas baloons, lighter-than-air, were provided with horizontal and vertical rudders, but such rudders did not perform the function of the Wright movable vertical rudder in combination with the marginal tips. However, apparatus of this description, even though provided with planes, and horizontal and vertical rudders, bears no close similarity to machines of the type under consideration as lateral balance is secured upon an entirely different principle.

In the description of the Harte British patent No. 1469, of 1870, it is stated that the wings of the machine when in operation form a single plane moving through the air in the direction of least resistance, and that they have hinged to the ends triangular extensions, called by the defendants aileron portions, which afford means for steadying the apparatus. While the extensions may be movable above and below the normal plane of the main body, yet there is no simultaneous manual control, and therefore, in my opinion, the described means do not correspond to the combination in claim 3 of the Wright patent, and as the vertical steering rudder of the Harte patent is not usable to maintain steadiness or balance, the elements of claims 7, 14, and 15 are not disclosed.

The Mouillard patent No. 582,757, for a glider, bears more particularly on claim 3 and is said to contain aileron portions on the sides of the planes. The description is of a monoplane surface with separate portions at the rear of each wing (light nets of silk twist J′ with meshes about 2 inches square under the frame of the wings) which are movable by cords extending to the operator. This structure was never reduced to practice. The specification in no way indicates that Mouillard considered the problem from the viewpoint of the patentees; nor does it show means for simultaneously increasing the lift of one aileron and depressing the other, or for simultaneously adjusting the ailerons above or below the horizontal plane; nor does it show the use of a rudder in connection with the depressible portions. The complainant's expert witnesses expressed the opinion that the despression of one wing operated to turn the apparatus, and not to balance it.

Much has been said by defendants of the Boulton British patent No. 392, of 1868, for aerial locomotion relating principally to the generation of the motive force used. The inventor of apparatus connected therewith appreciated the necessity for lateral stability in such constructions. Figure 5, attached to the drawing, shows vanes which are located on the sides of the machine and which constitute its ailerons. There are rudders which are designed to prevent the machine from being turned on its axis from the pressure of the air, and side vanes which may be turned around, according to the patent, like a "throttle valve." Defendants argue that such patent discloses the elements of claim 3 in suit, but complainant has shown with reasonable certainty that the pressure on the lateral vanes would be such as would not only turn one upward and the other downward, but that it would also pull the weight *d* (shown in Fig. 5) to one side with the result that the apparatus would become unbalanced. The side vanes of the patent to Boulton did not in my opinion suggest the lateral marginals of the patent in suit. While the vanes were operated from their normal position in a somewhat similar way to complainant's marginal wings when the apparatus was rotated, yet there was no manual control of the side portions as in complainant's machine. It is true, that the vanes are said to be operated by hand, although a self-acting mechanism in connection with their control is also specified but which I think was inoperative even though stops were used to prevent the vanes from completely turning or from moving to and fro. Although Boulton theoretically understood the probable disturbances due to air pressure, his self-acting mechanism for controlling and safely directing his machine amounted to little, and his assertions and suggestions were altogether too conjectural to teach others how to reduce them to practice, and therefore his patent is not anticipatory. American Graphophone Co. *v.* Leeds & Catlin Co., 170 Fed., 327. Nor does the Boulton structure weigh with me sufficiently to require a limitation of claim 3, for it is well settled that an invention or discovery set up in defense of infringement must have been complete, and capable of producing the desired result, and there is no such showing here. Coffin *v.* Ogden, 18 Wall, 120.

Importance is attached to the revived Mattulath application for a patent, dated January 8, 1900, but I think there is an utter failure to show that the catamaran-like structure of 180 feet over all and revolving disk 40 feet in diameter, with its decks, compartments and machinery, was complete, or that it was even remotely possible to reduce it to practice, and without such showing, it is devoid of material significance. Even assuming that it belongs to a prior art, the structure is not provided with movable side ailerons simultaneously adjustable, or a movable rudder, but has a fixed rudder which has no connection with the ailerons.

One additional publication, the Ader article, published in France in 1893, may be dwelt upon. The conception of Ader relates to apparatus for flying which somewhat resembles the wings of birds or bats having tips which, according to the specification, could be moved forward and backward. The machine was of the monoplane type and carried a motor, but as there was no connection between the warping features and the rudder by which the lateral balance of the machine was secured, the publication is not entitled to be considered in limitation of the claims in suit embodying such elements.

Challenging the claim of the patentees that equilibrium is maintained by the connection between the rear rudder and the warping tips, the defendants point to the Voisin machine (model exhibit)—a structure without warping means or its equivalent, but having a rear rudder for steering and maintaining balance. Such device, however, is provided with vertical end surfaces which impart lateral resistance to air pressure, while in complainant's and in defendants' aeroplanes the ends are open, the air passing through without resistance, and therefore the principle of operation in the Voisin structure is essentially different.

The Schroeder German patent of 1894 upon which the defendants lay stress, is for a gas balloon, a structure lighter than air, having a flat under surface and a slanting upper surface, a steering rudder operated by a single lever, and two wings, one at each end of the under side of the plane for maintaining equilibrium. Defendants' expert witness Waterman expressed the opinion that the Schroeder structure was readable on claims 3 and 7 of the Wright patent, and testified that the ailerons were movable automatically although if desired, they might be controlled by hand. The specification shows that in the center of the under side of the balloon there was suspended a car in which the operator was seated who by inclining his body from side to side obtained lateral balance by the movement of the wings which were automatically controlled by the tipping of the machine. The wings, which I think were merely incidental to the construction without being regarded as of the essence thereof, were mounted on a horizontal shaft extending from one end of the contrivance to the other, but they did not extend beyond the normal plane as do the ailerons of the defendants' machine. There is conflict of evidence as to whether such patent discloses means for simultaneously moving the rudder and the wings. From my examination thereof, I conclude that there was no such coordination between the vertical rudder and the wings as would enable their simultaneous movement to restore lateral balance. At any rate, as hereinbefore stated, there is a wide distinction between a gas containing machine designed for aerial navigation and an aeroplane. In the former there is a gradual descent to terra firma either from loss of gas or because of increased weight, while in an aeroplane the descent is precipitous in response to the law of gravity.

No useful purpose would be served by the consideration of other contrivances. A summary of what had gone before in aerial machinery unmistakably discloses, first, publications which did not contain descriptions of apparatus of such clearness and definiteness as to enable the skilled in the art to construct therefrom an operative device, or clearly suggesting ways or means to solve the problem of lateral balance, and second, exhibit patents which, as Judge Coxe says in Cimiotti Unhairing Co. *v.* American Unhairing Co., 115 Fed., 489, "immerged from oblivion solely to meet the exigencies of the occasion," and which contain undeveloped plans or ideas for constructions incapable of successful operation. As the defendants have not proven that the defects attributable to such devices could have been removed by the exercise of the skill and training of an engineer or mechanic, I am of opinion, after complete consideration of the testimony on both sides, that the patentees by their method of securing the equilibrium of the planes made an important advance in an embryonic art. They were not the first to conceive the idea of using monoplane or biplane surfaces for flying, nor the first to support two planes at their margins one above the other, or to use verticle tails or rudders for steering, or to place horizontal rudders forward of the machine to guide it upward or downward in its flight. The prior separate use of such elements is freely admitted by the patentees, but they assert, rightly I think, that the patented combination was a new combination performing a new and novel result. The antecedent patents, the efforts to perfect the gliding machine and to provide means for restoring equilibrium, in short, the many unsuccessful attempts to remedy existing imperfections in aerial machinery, all bear witness to the fact that the achievement of the patentees required the exercise of the inventive faculty. Having attained success where others failed, they may rightly be considered pioneer inventors in the aeroplane art. Their concept was practical, and their combination of old and new elements meritoriously advanced the operativeness of aeroplanes of this type from which astonishing flights have resulted.

Of course, it is not intended to decide, and such decision should not be inferred from what has been stated, that by the adaptation described in the specification and claims in suit the capsizing or upsetting of the aeroplane has been made impossible or its stability in the air positively assured, for this is not contended. But that the invention is a strong factor in restoring equilibrium where, owing to the fluctuations of the wind or to other disturbing causes, the aeroplane is shifted or swerved from its course, is undoubtedly proven. When such deflections occur, the warping device imparting to the aeroplane surface a helicoidal twist, is used, and at the same time the vertical rudder is turned to recover the equilibrium. And even if the patentees were not strictly pioneers in the sense of producing an apparatus novel in its entirety, they nevertheless strikingly surpassed their predecessors in devising means for restoring lateral balance and are entitled to a liberal construction of their claims in controversy and to the application of a range of equivalents that will include an aeroplane appropriating substantially the same instrumentalities and the same principle of operation.

The defendants urge that patentees' invention is without practical utility, that the flat planes described in the specification were never used, that the vertical rudder is useful merely to equalize resistance, that the patent fails to disclose the manner of effecting the equalization of the differences of air pressure, and argue that in turning complainant's machine the ailerons are warped with the result that the aeroplane swings or circles toward the side on which the greater angle of incidence was produced, that by such maneuvering to prevent upsetting complainant's machine has to be turned from its course, it being impossible to further turn the vertical rudder, and they argue that defendants' aeroplane is radically different from complainant's. They also claim that it was not until the vertical rudder was constructed to move independently of the ailerons, as in defendants' aeroplane, that an operative device was produced.

In the specification the surfaces of the planes are described as "normally substantially flat" and in the claims they are referred to as "normally flat", and it is stated that when the supporting surfaces are made of cloth or other flexible fabric a curvature is imparted to the planes by the resistance of the air. But the patentees did not limit themselves to the precise details of construction, and they stated in their specification that the same might be modified without departing from the principle of the invention. The patentees evidently believed that the curved surfaces would be made normally flat in view of the flexibility of the material originally used by them, and that to their surfaces there would be imparted a curvature by air pressure. They were required by law merely to state the best manner known to them of embodying their invention in a complete practical structure, and were not limited to the specific form, or to the best form known to them, if their claims were broad enough to entitle them to equivalents. Columbia Motor Car Co. *v.* C. A. Duerr & Co. *et al.*, 184 Fed., 893, 911.

The defendants assert that curved surfaces impart lifting advantages to the planes and also increase the stability of the planes, and that the patentees purposely refrained from disclosing the best form of their apparatus, intending by a faulty description to mislead the public. In answer, however, it suffices that the evidence does not support any such view.

To the aeroplanes later constructed by the complainant there has been added a supplemental lever for turning the vertical rudder, which, as shown by the evidence, is used to increase the swing of the machine in one direction or another when the conditions are such as to necessitate turning the rudder further to the right or left to retard the speed of the right or left wings than can be done by using the cradle. This alteration or additional feature was not necessary to the practicability or operativeness of the invention, such rudder still being relied upon in connection with the warping instrumentality.

Defendants further contend that the patent is silent regarding the use of a motor and that therefore it was never intended to pass beyond the gliding machine stage, but this is incorrect as the specification expressly alludes to flying either by the application of mechanical power or gravity. Moreover, the use of motors in aerial machinery was not a new idea, and was never regarded as a knotty problem.

There was much discussion at the bar as to claim 3 which does not include the vertical rudder as an element. The important feature thereof is that the lateral marginal portions of the planes must be capable of movement to different angles relatively to the normal plane of the aeroplane and about an axis transverse to the line of flight, the purpose of said movements being to present to the atmosphere different angles of incidence. It was argued that without the co-operation of the vertical rudder the claim was wholly impracticable. The complainant company, to the contrary, rejoins that there is shown a sub-combination which is valid and which should be sustained. There is evidence that the marginal ends of the supporting planes are capable of moving simultaneously in different angular relations to the plane and to each other without the assistance of the vertical rudder, but the result was not satisfactory as the machine in its flights skidded to the side, an imperfection which has been remedied by the use of the vertical rudder in conjunction with the ailerons. It is not essential to the validity of claim 3 that all parts of the machine, or all parts specified in other claims, which are necessary to its operativeness should be included therein, and resort must be had to the specification for a disclosure of the parts necessary to insure the practicability of a patented device. In the Wright structure a new and novel result was attained simply by having the ailerons on the ends of the planes without the supplemental feature of the vertical rudder. The warping feature is, in fact, the essential part of the machine while the vertical rudder insuring successful flying is a valuable adjunct without which lateral balance could not be restored. The employment, in a changed form, of the warping feature or its equivalent by another, even though better effects or results are obtained, does not avoid infringement. In such circumstances, as I read the authorities, the claim is valid as a combination. Thompson-Houston Electric Co. *v.* Black River Traction Co., 135 Fed., 759; Deering *v.* Winona Harvester Works, 155 U. S., 286; Taylor *et al. v.* Sawyer Spindle Co., 75 Fed., 301. In Railroad Co. *v.* Dubois, 12 Wall., 47, the Supreme Court of the United States says:

> "Undoubtedly a patentee may claim and obtain a patent for an entire combination, or process, and also for such parts of the combination or process as are new and useful, and he may claim and obtain a patent for both."

In Thompson-Houston Electric Co. *v.* Black River Traction Co., *supra,* Judge Wallace, writing for the Circuit Court of Appeals, said:

> "Many sub-combinations, although new, are not useful except to perform their ap-

propriate functions in the machine of which they are a part. The description in the patent of the whole machine, and of the means or mode by which the sub-combination is brought into co-operative relation with the other parts, usually indicates how the sub-combination may effect a useful result. When this is so the combination need not be operative alone, because (to use the language of Mr. Walker) 'utility is justly ascribed to things which have their use in co-operating with other things to perform a useful work.' In Taylor *v.* Sawyer Spindle Co., 75 Fed., 301, 22 C. C. A., 203, in considering the objection that the claims by themselves were void because not composing an operative mechanism, the court said: 'The law upon this subject is too well settled to be open for discussion. A patentee is not required to claim the entire machine in each claim. Each of the claims at issue is for a complete combination of the spindle and its supporting tube and devices, and there was no necessity for expressing in terms the devices for revolving the spindle. Any appropriate means for operating it will be understood. The omission of the sleeve wheel does not affect the validity of either of the claims, which belong to that class where reference may be made to the specification to supply in a claim what is plain to any one skilled in the art.' "

To a similar effect, see Canda *et al.* *v.* Michigan Malleable Iron Co., 124 Fed., 486, and Clark Blade & Razor Co. *v.* Gillette Safety Razor Co., 194 Fed., 421. The doctrine of such adjudications may appropriately be applied to the situation presented herein. Consideration has already been given the patents to Mouillard and Boulton which show lateral extensions and which, it is asserted, limit claim 3, and nothing further need be added to the criticism elsewhere made.

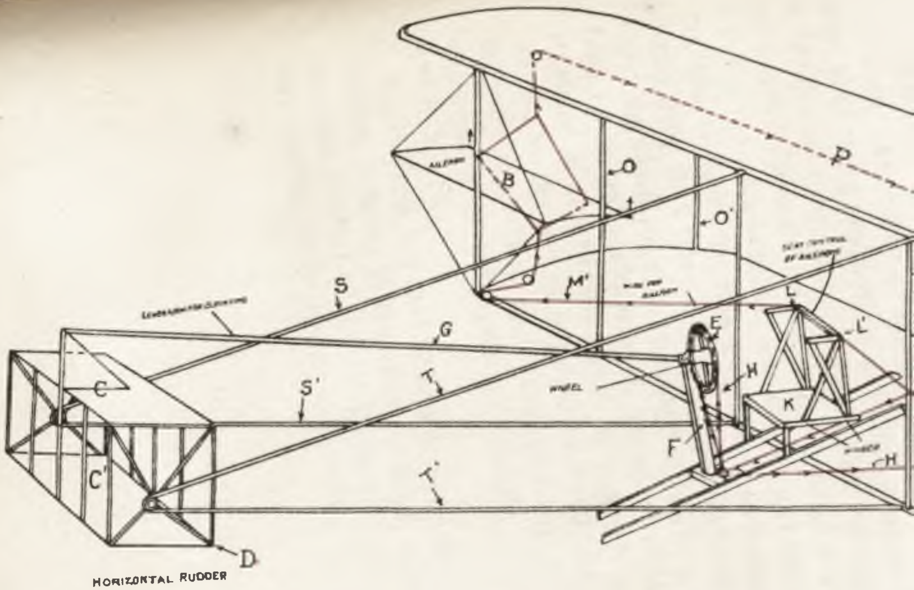
It is next contended that defendants' aeroplane does not infringe claim 3 as its ailerons do not move in either directions above or below the normal plane of the body portion, but any such alteration, however, is immaterial as defendants' planes move at different angles relative to the aeroplane and to each other and attain the substantial result of the Wright patent.

Claim 7 in for the elements of (1) an aeroplane, (2) means for moving the ailerons in different directions, (3) a vertical rudder, and (4) means for operating the rudder causing it to "present to the wind that side thereof nearest the side of the aeroplane having the smaller angle of incidence and offering the least resistance to the atmosphere, substantially as described." The description of the *modus operandi* of the rear rudder plainly discloses its object and purpose and is not restricted to the warping ropes or wires. Claim 14 includes the horizontal rudder with means for presenting its under side to the resistance of the air currents, while claim 15 specifies the location on the aeroplane of the vertical and horizontal rudders. The said claims must be given an interpretation of sufficiently wide scope to cover the appropriation of the substance of the invention or the equivalent means by which the principle is applied to an aeroplane of the type described in the patent in suit.

This brings me to the final question of whether or not there is in defendants' machine a tendency to spin or swerve which is checked or counteracted by the operation of its vertical rudder. Upon this phase of the case considerable oral testimony was given bearing upon the practical and theoretical sides. Notwithstanding the construction to which the claims are thought entitled, if the defendants operated their aeroplane upon a different principle using means which were old in aerial navigation or foreign to complainant's, then infringement cannot be sustained.

The evidence is that the defendants in their machine have two slightly curved planes supported by rigid posts placed vertically to the planes at the front and rear sides, the ends thereof being open the entire length, and that there are two ailerons or wings on the extreme sides of the planes each pivoted to supports and crosspieces midway between the upper and lower planes. Such ailerons or supplementary planes are extended in part beyond the edges of the main planes, and are not continuous or integral portions thereof as are complainant's. They are adjustable at different angles and are raised and lowered by the lateral movement of the body of the aviator who is seated in a movable seat in the central portion of the aeroplane. Each aileron has the same angle to the supporting props as the other, and as the angles of incidence of the planes change in flying the angles of the ailerons also change, each presenting unequal angles and resistances. In consequence of such variation in the angles of the ailerons, the speed of the high and low sides varies whenever the planes are tilted from the normal angle. At the rear of defendants' construction there is a vertical rudder, and there is a sharp question of fact as to whether such rudder is used to assist the ailerons in recovering lateral balance by retarding the speed of the high side and increasing the speed of the opposite side. If it is not so used, then in my opinion the defendants' machine is not operated on the principle of claims 7, 14, and 15 in suit. The claim is that such rudder is operated in a manner to compensate for the difference in head resistance on the ailerons due to the unequal angles caused by the continuous alteration of the angle of incidence of the machine, or, in other words, that the defendants' rudder is turned to the high side because of the unequal resistance exerted by the ailerons. This mode of operation the defendants earnestly deny, and there is much dispute in regard thereto.

In front of their machine the defendants also use a horizontal rudder which directs the upward and downward course and which may be maneuvered by the aviator to co-act with the ailerons and the vertical rudder. The following is a perspective view of defendants' machine:



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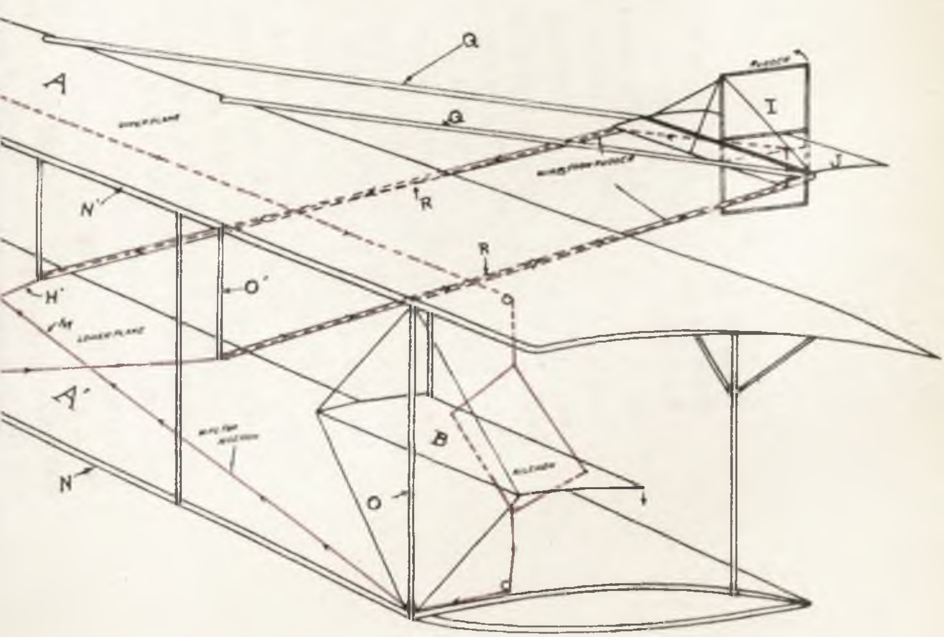

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If I am correct in my interpretation of claim 3 and the rule of law applicable thereto, the ailerons of defendants' construction and the manner of using them are within its scope. The witness Curtiss frankly testified that the purpose thereof is to preserve the lateral balance "without the use of any other element or part", it making no difference whether the aeroplane is in a straight or curved flight. Such concession supports the asserted infringement of the claim under consideration. There is, however, other testimony showing the specific manner in which the result is attained. The witnesses for complainant have sworn that in defendants' construction the aviator to restore lateral balance causes the ailerons to be lowered or raised, thus increasing the angle of incidence of one while decreasing that of the other, by inclining his body and moving his seat towards the high wing. It is true that the vertical rudder is not connected so as to co-act with the ailerons, there being no direct connection between them, but each is controlled separately. According to the evidence, a turning effect is at times produced in defendants' machine by air disturbances, to counteract which the right aileron of defendants' machine may be pulled downward as the other is raised, and the vertical rudder inclined towards the raised aileron. Defendants firmly deny that there is any turning tendency or swerving which requires turning the rudder away from its central position; and, giving effect to the language of the Circuit Court of Appeals in its opinion on the appeal to be relieved from the preliminary injunction, upon this point really hangs the question of infringement. Wright *v.* Curtiss, 180 Fed., 110.

Curtiss testified that he had given particular attention in flying to the ailerons of his machine to acquaint himself with their movements and to find out whether they caused a swerving of the machine on its vertical axis which in its correction necessitated the use of the rear rudder, and he swears that the rear rudder is not used to assist the ailerons in their functions or to restore equilibrium, but merely for steering. The witness Willard, who has many times flown a Curtiss aeroplane, swears that in recovering balance there is no swerving or turning on the vertical axis, and that in effecting such maneuver the vertical rudder is held in a central position; that he has never noticed any tendency of the machine to swerve because of the use of the ailerons, and in support of his testimony he cited an instance of the breakage of the controlling wires leading to the vertical rudder, and said that he flew ahead for a distance of two miles without its use; but as an equalizing device was used and as the ailerons in the machine used were differently placed than midway between the planes, the incident loses importance. Captain Beck of the Government Aviation Station, who has flown the defendants' aeroplane, substantially testified that there were no deviations of the aeroplane from its course owing to the use of the ailerons; that the vertical rudder was not used to counteract any turning or swerving due to their use, and that he had never made such use of the vertical rudder, but he admitted that on one occasion in climbing he tilted abnormally and turned his rear rudder in the opposite direction to restore balance, and succeeded in doing so. Lieut. Ellyson of the United States Navy also testified that he noticed no swerving when flying, and that the vertical rudder in the Curtiss aeroplane is usually used in starting from the ground, but not in flying, except for steering purposes. The witness Post testified that from his observations in experimental tests he could testify positively that there is no turning of the machine around a vertical axis when the balancing planes are used, and that the rudder is used solely for steering.

The testimony of witnesses who have flown the defendants' aeroplane and swear that the rear rudder is not in fact used for recovering lateral balance, but that such function is performed solely by the ailerons, would ordinarily be entitled to greater weight than the opinions of experts or the contradictory testimony of witnesses who were on the ground or in other flying machines observing the movements of the defendants' machine, or than the statements made by others in relation to the manner in which such machine should be, or had been operated, and would in this case, were it not that there is cogent evidence tending to modify or qualify their denials of the use of the vertical rudder except for steering. Willard concedes that the rear rudder is turned to the high side to gain additional restoring power; that it is used as "a separate agent to accomplish a desired result more quickly or more positively." In the Curtiss letter in evidence it is substantially admitted that the rear rudder is turned toward the high side at times *to assist in balancing* the machine by steering or turning.

The testimony of Lieut. Milling of the United States Signal Corps Aviation School, who has frequently flown in both Wright and Curtiss machines, strongly supports the claim that the defendants employ the vertical rudder for the dual purpose of steering and recovering balance under certain conditions. I quote therefrom concerning the method of flying the Curtiss machine. He says:

> "I move the aileron on the low wing in order to increase the angle of lift and move the vertical rudder toward the other side until the machine resumes a horizontal position" and move "the aileron on the other side in the opposite direction * * * On two or

three occasions, in very gusty weather, I have allowed the wing to remain in the position assumed when pressed down by a down trend of air and have attempted to raise it by using only the ailerons. I held it in this position without touching the vertical rudder as long as I felt it to be safe, without any response. By moving the vertical rudder toward the high side, the machine resumed a horizontal position immediately."

This would seem to bear out the assertion that the rear rudder is used to correct the differences of resistance, and not merely to recover from an unusual tilt due to untoward causes. Although Lieut. Milling subsequently stated that under ideal weather conditions it is not necessary in the Curtiss machine to use the rear rudder in balancing, still, giving consideration to all the evidence, I am led to the conclusion that notwithstanding the claim of the defendants that turning the rudder to the high side results in the performance of a different function than in complainant's machine, the fact is clear that it does on occasion assist the ailerons in restoring equilibrium. That it is capable of action separately from the ailerons, or that it is turned to the high side only on extraordinary occasions, or that it is primarily for use in steering and only incidentally to assist in restoring balance when abnormally tilted does not avoid infringement.

The wheel by which the rudder is turned and to which it is connected by wires, is positioned directly in front of the machine and is adapted for movement practically at the same time with the ailerons, and thus the rear rudder and ailerons are capable of substantial co-ordination. It is true that none of the claims specifically state that the vertical rudder should be turned to the high side to recover the balance of the machine or to keep it balanced, yet in claims 7, 14 and 15 means are included for moving it to the side of least resistance which the evidence shows was the high side, the greater angle of incidence being the low side as the pressure caused the machine to go faster on the high side and necessitated counterbalancing, or checking such tendency. That the vertical rudder of defendants' machine at times operates on this principle is fairly substantiated. It is not unlikely that its ailerons produce a more effective result than do those of complainant's machine and that the vertical rudder is not as often resorted to for maintaining or restoring balance, but nevertheless the evidence shows that there are times when the rudder is turned to the high side to prevent that side from flying faster than the opposite side and by exerting an influence upon the ailerons assists them in their functions.

To further differentiate their machine from complainant's, the defendants assert that in their aeroplanes there is no normal difference in the angle of incidence to the course of travel as in complainant's, as their ailerons are directly in the "streamline" and have no unequal pressures which tend to cause the machine to turn or swerve, and it is argued that the problem of the patentees was different from the problem solved by Curtiss, in that the machine of the former is steered by its wing tips and vertical rudder, while that of the latter is steered wholly by the rudder. But, as elsewhere shown, this argument is not entirely substantiated by the facts. It is true that in complainant's machine the vertical rudder is turned to the right when the course of the machine is to the left, while the Curtiss machine responds to the direction of its rudder. This difference, however, is not of controlling importance, and does not establish a patentable differentiation. With a knowledge of the principle of the patent in suit and a familiarity with the method of operation of the marginal ends of the planes, it is not likely that there was much difficulty in making the supplementary planes of the defendants' machine in such a way as to avoid a difference in the normal angle of incidence by putting the planes in the "stream-line." Such alterations or modifications, however, in view of the latitude of the claims, did not constitute fundamentally different modes of operation from those described in the Wright specification.

The defendants are believed to have appropriated the substance of claim 7, and to have infringed claim 14, inasmuch as in addition to the esential elements of the Wright patent and the object with which such elements are used, they also employ in their aeroplane, as hereinbefore shown, a horizontal rudder for "presenting its upper and under surfaces to the resistance of" the atmosphere. Claim 15 contains the essential elements and specifies the location of a vertical rudder at the rear of the machine and a horizontal rudder at the front thereof.

The defendants have embodied in their aeroplane the various elements of the claims in suit. While it is true, as pointed out herein, that the defendants have constructed their machine somewhat differently from complainant's and do not at all times and on all occasions operate the same on the Wright principle, yet the changes they have made in their construction relate to the form only. They have constructed their machine so that it is capable of restoring equilibrium in substantially the same way as in complainant's machine, and the evidence is that on occasions, depending upon aerial conditions or other disturbing causes, they use the vertical rudder not only to steer their machine, but to assist the ailerons in restoring balance.

It is unnecessary to further answer the arguments advanced at the bar bearing on the defense of non-infringement as to do so would extend this opinion beyond reasonable length. Everything relating to the testimony and the criticisms thereon has not been fully treated, yet the material features have been sufficiently elaborated. The questions of law in the case are important, but the questions of fact are controlling, and in view of the novelty of the claims and their scope, the question of infringement is resolved adversely to the defendants as to the claims which are the subject of this controversy.

A decree may be entered, with costs, in favor of the Wright Company as prayed in the bill, but because of the importance of the litigation and of the questions involved, a supersedeas will be allowed upon condition that an appeal be diligently prosecuted.

Dated, Feb. 21st, 1913.

John R. Hazel,
D. J.

(Endorsed.)—United States District Court, Western District of New York.—In Equity No. 400.—The Wright Company, Complainant, against The Herring-Curtiss Company and Glenn H. Curtiss, Defendants.—Opinion.—Hazel, *J.*—Filed Feb 21 1913.—S. W. Petrie, Clerk.

UNITED STATES DISTRICT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY,
Complainant,

vs.

THE HERRING-CURTISS COMPANY and GLENN H. CURTISS,
Defendants.

SIR:

PLEASE TAKE NOTICE that the proposed decree, of which a copy is herewith served upon you, will be presented to the Court for settlement and entry at a term thereof to be held for the hearing of motions in the Court House in the City of Buffalo, New York, on Tuesday the 1st day of April, 1913, at 10 o'clock in the forenoon of that day, or as soon thereafter as counsel can be heard.

Yours, etc.,
EDMUND WETMORE,
Counsel for Complainant,
No. 34 Pine Street,
New York, N. Y.

To EMERSON R. NEWELL, Esq.,
Solicitor for Defendants,
No. 2 Rector Street,
New York City.

At a Stated Term of the District Court of the United States for the Western District of New York, held in and for the said District, at the Court Rooms thereof in the City of Buffalo, New York, on the 8th day of April, 1913.

Present—HONORABLE JOHN R. HAZEL, *Judge.*

THE WRIGHT COMPANY,
Complainant,

vs.

THE HERRING-CURTISS COMPANY and GLENN H. CURTISS,
Defendants.

This suit having come on to be heard at the November Term, 1912, of this Court upon the pleadings, proceedings and proofs herein, after hearing Frederick P. Fish, Esq., Edmund Wetmore, Esq., and H. A. Toulmin, Esq., counsel for complainant, and J. Edgar Bull, Esq., and Emerson R. Newell, Esq., counsel for defendants, it is, upon consideration, and upon motion of H. A. Toulmin, solicitor for the complainant, ORDERED, ADJUDGED and DECREED as follows:

FIRST: That the Letters Patent of the United States issued in due form of law to Orville Wright and Wilbur Wright on May 22, 1906, No. 821,393, for Improvements in Flying Machines are good and valid, and that the title to said Letters Patent is duly vested in the complainant.

SECOND: That the defendants, The Herring-Curtiss Company and Glenn H. Curtiss have infringed upon the third, seventh, fourteenth and fifteenth claims of said Letters Patent by jointly selling or making, using, or causing to be made, used or sold, exhibiting, or causing to be exhibited, without right or license, flying machines embodying and containing the inventions covered in and by said claims of said Letters Patent No. 821,393.

THIRD: That the complainant do recover of the said defendants the profits which they the said defendants or either of them have derived, received or made by reason of the aforesaid joint infringement of said Letters Patent, and that said complainant do also recover of said defendants any and all damages it has sustained by reason of said joint infringement by said defendants; and it is hereby referred to Harris S. Williams, as a Master of this Court, to state and report to the Court an account of such profits, and to ascertain and report such damages with all convenient speed; and the said defendants and each of them are hereby directed and required to attend before said Master from time to time as required, and produce before him such books, papers and documents as relate to the matters at issue, and to submit to such oral examination as the Master may require.

FOURTH: That a perpetual injunction issue out of and under the seal of this Court enjoining the defendants, The Herring-Curtiss Company and Glenn H. Curtiss, their officers, attorneys, clerks, servants, agents, employees and workmen, and each of them, from directly or indirectly manufacturing, using or selling, or causing to be made, used or sold, and from exhibiting, offering to exhibit, practising, flying or otherwise utilizing, machines made in accordance with, or embodying the inventions described in the said Letters Patent No. 821,393, and claimed in the said third, seventh, fourteenth and fifteenth claims thereof, which are as follows:

"3. In a flying-machine, a normally flat aeroplane having lateral marginal portions capable of movement to different positions above or below the normal plane of the body of the aeroplane, such movement being about an axis transverse to the line of flight, whereby said lateral marginal portions may be moved to different angles relatively to the normal plane of the body of the aeroplane, and also to different angles relatively to each other, so as to present to the atmosphere different angles of incidence, and means for simultaneously imparting such movement to said lateral marginal portions, substantially as described.

"7. In a flying-machine, the combination, with an aeroplane, and means for simultaneously moving the lateral portions thereof into different angular relations to the normal plane of the body of the aeroplane and to each other, so as to present to the atmosphere different angles of incidence, of a vertical rudder, and means whereby said rudder is caused to present to the wind that side thereof nearest the side of the aeroplane having the smaller angle of incidence and offering the least resistance to the atmosphere, substantially as described.

"14. A flying-machine comprising superposed connected aeroplanes, means for moving the opposite lateral portions of said aeroplanes to different angles to the normal planes thereof, a vertical rudder, means for moving said vertical rudder toward that side of the machine presenting the smaller angle of incidence and the least resistance to the atmosphere, and a horizontal rudder provided with means for presenting its upper or under surface to the resistance of the atmosphere, substantially as described.

"15. A flying-machine comprising superposed connected aeroplanes, means for moving the opposite lateral portions of said aeroplanes to different angles to the normal planes thereof, a vertical rudder, means for moving said vertical rudder toward that side of the machine presenting the smaller angle of incidence and the least resistance to the atmosphere, and a horizontal rudder provided with means for presenting its upper or under surface to the resistance of the atmosphere, said vertical rudder being located at the rear of the machine and said horizontal rudder at the front of the machine, substantially as described."

and from infringing said claims of said Letters Patent in any way whatsoever.

FIFTH: That the complainant recover of the defendants its costs and disbursements in this suit to be taxed by the Clerk of this Court.

SIXTH: Because of the importance of the litigation and the questions involved, a supersedeas is allowed upon condition that an appeal is promptly taken and diligently prosecuted, the bond on said supersedeas to be in the sum of Ten Thousand Dollars ($10,000).

JOHN R. HAZEL,
D. J.

This is the decree settled April 8th.
E. R. N.
Apr. 16/13.

(Endorsed)—(C. C.) Eq. 400 United States District Court, Western District of New York.—

The Wright Company, Complainant, *vs.* The Herring-Curtiss Company and Glen H. Curtiss, Defendants.—Decree and Notice of Settlement.—Edmund Wetmore, Counsel for Complainant, 34 Pine Street, New York City.—Filed Apr. 17 1913.—S. W. Petrie, Clerk.—Wetmore & Jenner, 34 Pine Street, New York.—Service of a copy of the within decree and notice of settlement, this 26th day of March, 1913, is hereby admitted.—Emerson R. Newell by C. T. B.

UNITED STATES DISTRICT COURT.

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY vs. THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.	In Equity No. 400.

SUPERSEDEAS ORDER.

A decree herein having been settled on April 8th, 1913 ordering that an injunction issue against the Defendants herein, said order also specifying that a supersedeas be granted pending appeal upon Defendants filing a bond for Ten Thousand Dollars ($10,000.), and said bond having been filed, and approved as to the security by this Court.

NOW, THEREFORE, on motion of Emerson R. Newell, Counsel for Defendants, it is hereby

ORDERED that the injunction be suspended until the further order of this Court.

JOHN R. HAZEL,
U. S. Judge.

Dated, April 17, 1913.

(Endorsed)—C. C. Eq. 400.—United States District Court Western District of New York.—The Wright Company *vs.* The Herring-Curtiss Company and Glenn H. Curtiss.—In Equity No. 400.—Supersedeas Order.—Emerson R. Newell, Sol. & Counsel for Defts., No. 2 Rector St., N. Y. City.—Filed Apr. 17, 1913.—S. W. Petrie, Clerk.

DISTRICT COURT OF THE UNITED STATES OF AMERICA

FOR THE WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY, Complainant, vs. THE HERRING-CURTISS COMPANY and GLENN H. CURTISS, Defendants.	In Equity No. 400.

KNOW ALL MEN BY THESE PRESENTS, That the American Surety Company of New York, a corporation organized and existing under the laws of the State of New York, and having a principal office at No. 100 Broadway in the City of New York, N.

Y., is held and firmly bound unto the above named The Wright Company in the sum of Ten Thousand Dollars ($10,000) to be paid to the said The Wright Company, for the payment of which well and truly to be made, it binds itself, its successors and assigns, jointly and severally, firmly by these presents.

SEALED with its seal and dated this 15th day of April, in the year of our Lord, one thousand nine hundred and thirteen.

WHEREAS, the above named The Herring-Curtiss Company and Glenn H. Curtiss, are about to prosecute an appeal to the United States Circuit Court of Appeals for the Second Circuit, to reverse the decree settled April 8th, 1913, granting a permanent injunction against them on Wright Patent No. 821,-393 by the Judge of the District Court of the United States for the Western District of New York;

NOW, THEREFORE, THE CONDITION OF THIS OBLIGATION IS SUCH, That if the above named The Herring-Curtiss Company and Glenn H. Curtiss shall prosecute said appeal to effect, and answer all damages and costs not exceeding Ten Thousand Dollars ($10,000.00) if it shall fail to make said appeal good, then this obligation shall be void, otherwise the same shall be and remain in full force and virtue.

AMERICAN SURETY COMPANY OF NEW YORK,
By R. S. DONALDSON,
Resident Vice President.

Attest: G. A. MCCLANATHAN,
Resident Assistant Secretary.

STATE OF NEW YORK,
Erie County,
City of Buffalo, } ss.:

On the 15th day of April, in the year 1913, before me personally came R. S. Donaldson, to me known, who, being by me duly sworn, did depose and say: That he resided in the City of Buffalo, N. Y.; that he is the Resident Vice-President of the American Surety Company of New York, the corporation named in and which executed the within instrument; that he knew the seal of said corporation; that the seal affixed to said instrument was such corporate seal; that it was so affixed by order of the Board of Directors of said corporation and that he signed his name thereto by like order; and that the liabilities of said Company do not exceed its assets as ascertained in the manner provided in Section 3 of Chapter 720 of New York Session Laws of the year 1893. And the said R. S. Donaldson further said that he was acquainted with G. A. McClanathan and knew her to be Resident Assistant Secretary of said Company; that the signature of the said G. A. McClanathan subscribed to the said instrument is in the genuine handwriting of the said G. A. McClanathan, and was subscribed by the like order of the said Board of Directors, and in the presence of him, the said R. S. Donaldson.

CHARLES M. DIVINS,
Commissioner of Deeds in and for
the City of Buffalo, N. Y.

STATE OF NEW YORK,
County of New York, } ss.:

H. A. REISS, being duly sworn, says: That he is an Assistant Secretary of the American Surety Company of New York; that said Company is a corporation duly created, existing and engaged in business as a surety company under and by virtue of the laws of the State of New York, and has duly complied with all the requirements of the laws of said State applicable to said Company, and is duly qualified to act as surety under such laws. That said Company has also duly complied with and is duly qualified to act as surety under the Act of Congress of August 13, 1894, entitled "An Act relative to recognizances, stipulations, bonds and undertakings and to allow certain corporations to be accepted as surety thereon;" that the within is a true copy of the last statement of the assets and liabilities of said Company as rendered pursuant to section 4 of said Act of Congress; that said statement is true and that said American Surety Company of New York is worth more than $6,000,000 over and above all its debts and liabilities and such exemptions as may be allowed by law.

H. A. Reiss.

Subscribed and sworn before me this 9th day of April, 1913.

E. A. Farrell,
Notary Public,
New York County, No. 1058,
Register's Office, New York County, No. 5015,
Certificate filed in all counties.

Incorporated April 14, 1884.

AMERICAN SURETY COMPANY OF NEW YORK,

General Offices, 100 Broadway.

Financial Statement, March 31, 1913.

Resources.

Real Estate,		
Home Office Building and Land, unencumbered	$3,000,000.00	
N. Y. City Water Front, unencumbered	166,047.91	
		$3,166,047.91

Stocks and Bonds, Market Value....	3,823,935.75
Guaranteed Mortgages, and Collateral Loans	206,276.36
Cash in Banks and Offices..........	1,013,710.34
Premiums in Course of Collection...	555,014.71
Accrued Interest and Rents........	58,059.08
	$8,823,044.15

Liabilities.

Capital Stock......................	$5,000,000.00
Surplus	1,267,227.61
Reserve for Re-Insurance..........	1,714,001.77
Reserve for Contingent Claims.......	699,198.11
Reserve for Contingent Expenses....	60,000.00
Bills and Accounts Payable, not due..	82,616.66
	$8,823,044.15

EXTRACT FROM THE RECORD BOOK OF THE BOARD OF TRUSTEES OF THE

AMERICAN SURETY COMPANY OF NEW YORK.

The first meeting of the Board of Trustees of the American Surety Company of New York, after the annual Stockholders' meeting, was held at the office of the Company, No. 100 Broadway, New York City, on Tuesday, January 21, 1913, at eleven o'clock A. M.

"The Secretary read the report of the Nominating Committee as follows:

"To the Board of Trustees of the
AMERICAN SURETY COMPANY OF NEW YORK,

"GENTLEMEN:

"The Committee appointed by the Executive Committee of this Company at their meeting held

Tuesday, December 10, 1912, for the purpose of nominating * * * officers of the Company, * * * for the ensuing year and until their successors are elected, beg leave to report as follows:

"We nominate for * * *

PLACE.	RESIDENT VICE PRESIDENTS.	RESIDENT ASSISTANT SECRETARIES.
Buffalo, N. Y.	Clinton B. Gibbs	Z. L. Tidball
	Z. L. Tidball	H. L. Hart
	Herbert L. Hart	G. A. McClanathan
	Robert S. Donaldson	Chas. M. Divins
	C. S. Cadwallader	

* * * * * * *

"WHEREUPON, it was

"RESOLVED, that the Secretary be authorized to cast one ballot on behalf of the Trustees present, for the Members of the Executive Committee, Finance Committee, Committee on Accounts, Committee on Capital Box, Officers and Counsel, as recommended by the Nominating Committee for the ensuing year and until their successors are elected; which was done, and thereupon the aforementioned persons were declared to have been unanimously elected to their respective offices for the ensuing year and until their successors are elected.

* * * * * * *

"The following resolution was adopted:

"RESOLVED, that the Resident Vice-Presidents be and they hereby are, and each of them is hereby, authorized and empowered to execute and to deliver and to attach the seal of the Company to any and all obligations for or on behalf of the Company, such obligations, however, to be attested in every instance by the Resident Assistant Secretary."

* * * * * * *

STATE OF NEW YORK, } ss.:
County of New York, }

I, H. A. REISS, Assistant Secretary of the American Surety Company of New York, do hereby certify that I have compared the foregoing extracts and transcripts, from the Record Book of the Board of Trustees of the American Surety Company of New York, with the original record of said Board, and that the same are correct extracts and transcripts therefrom as they appear of record and are set forth and contained in said Record Book; and I further certify that I have compared the foregoing resolutions with the originals thereof, as recorded in the Minute Book of said Company, and do certify that the same is a correct and true transcript therefrom, and of the whole of said original resolutions; and that the said resolutions have not been revoked or rescinded.

Given under my hand and the seal of the Company, at the City of New York, this 31st day of January, 1913.

H. A. REISS,
Assistant Secretary.

(Endorsed.)—(C. C.) Eq. 400.—District Court of the United States of America for the Western District of New York.—The Wright Company, Complainant *vs.* The Herring-Curtiss Company and Glenn H. Curtiss, Defendants, Undertaking on Appeal American Surety Company of New York.—H. L. Hart, Manager for Western New York, 701-703 White Building, Buffalo, N. Y.—Filed Apr. 17, 1913.—S. W. Petrie, Clerk.—The Within Bond is Approved as to Form and Sufficiency of Sureties this 15 day of Apr. 1913.—John R. Hazel, *D. J.*

UNITED STATES DISTRICT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY vs. THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.	In Equity. #400.

SUPERSEDEAS ORDER.

Defendants having filed a bond for Ten Thousand Dollars ($10,000.), and having taken their appeal to the United States Circuit Court of Appeals for the Second Circuit from the decree dated April 17, 1913, it is, on motion of Emerson R. Newell, Esq., Counsel for Defendants, hereby

ORDERED that until otherwise ordered all proceedings in this cause be stayed pending said appeal and until the handing down of the mandate upon the same.

JOHN R. HAZEL,
U. S. Judge.

Dated April 23, 1913.

(Endorsed)—United States District Court, Western District of New York.—The Wright Company *vs.* The Herring-Curtiss Company and Glenn H. Curtiss.—In Equity #400.—Supersedeas Order.—Emerson R. Newell, Sol. & Counsel for Defendants.—Filed May 13, 1913. —S. W. Petrie, Clerk.

UNITED STATES DISTRICT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY vs. THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.	In Equity. #400.

PETITION FOR APPEAL.

THE HERRING-CURTISS COMPANY and GLENN H. CURTISS, the above-named Defendants, conceiving themselves aggrieved by the decree dated April 8th, 1913, in the above-entitled cause, hereby appeal from said decree to the United States Circuit Court of Appeals for the Second Circuit, for the reasons specified in the Assignment of Errors filed herewith, and they pray that this appeal may be allowed and that the transcript of record, proceedings, exhibits and papers upon which said decree was made, duly authenticated, may be sent to the United States Circuit Court of Appeals for the Second Circuit.

EMERSON R. NEWELL,
Solictor & Counsel for Defendants,
#2 Rector Street,
New York, N. Y.

The foregoing claim of appeal is allowed this 23rd day of April, 1913.

JOHN R. HAZEL,
U. S. Judge.

UNITED STATES DISTRICT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY vs. THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.	In Equity. #400.

ASSIGNMENT OF ERRORS.

Now comes The Herring-Curtiss Company and Glenn H. Curtiss, the above-named Defendants, by their Solicitor, Emerson R. Newell, and having prayed an appeal to the United States Circuit Court of Appeals for the Second Circuit from the decree of this Court dated the 8th day of April, 1913, wherein an injunction was directed to issue against these Defendants, respectfully represents as Assignments of Error therein, that said District Court erred in the following particulars:

(1) As to each of Claims 3, 7, 14 and 15 of the patent in suit,—in holding that said claim is valid and has been infringed, and in not holding that said claim is not valid or has not been infringed;

(2) In holding that the mode of operation of Defendants' machine is substantially the same as that of the machine disclosed in the patent in suit, and in not holding that the mode of operation of Defendants' machine is substantially different from that of the machine disclosed in the patent in suit;

(3) In holding that the prior art did not substantially disclose the combinations claimed in Claims 3, 7, 14 and 15;

(4) In not holding that Claims 14 and 15 are limited to a biplane construction having a movable marginal portion at each end of each plane;

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(5) In holding that the ailerons of Defendants' machine cause the machine to turn on its vertical axis and require the vertical rudder to be turned to counteract such action;

(6) In holding, because Defendants' rudder is sometimes turned at the same time as the ailerons are used, that this fact proves that the ailerons and rudder co-operate substantially as in the patent in suit;

Concedes

See Wright Rec. p. 529.

(7) In giving a broad interpretation to the claims, in view of the fact that the patentees did not disclose in the patent in suit the best form of their machine, but concealed information necessary to a legally complete disclosure;

(8) In accepting "Complainant's Exhibit, Complainant's Patent" (an alleged copy certified by the Patent Office) as sufficient proof of the original patent in suit, in the face of timely objection to it as secondary evidence (See page 20 Complainant's Printed Record), and without explanation of why the original was not produced;

(9) In awarding damages, profits and costs to Complainant;

(10) In not dismissing the Bill of Complaint.

WHEREFORE said Defendants pray that said decree may be reversed in the particulars heretofore set forth.

EMERSON R. NEWELL,
Solicitor & Counsel for Defendants,
#2 Rector Street,
New York City,
New York.

Dated N. Y., April 23, 1913.

Service of a copy of the foregoing Petition for Appeal, Allowance, and Assignment of Errors acknowledged this 10th day of May, 1913.

H. A. TOULMIN,
Solicitor for Complainant-Appellee.

(Endorsed)—United States District Court, Western District of New York.—The Wright Company *vs.* The Herring-Curtiss Company and Glenn H. Curtiss.—In Equity #400.—Petition for Appeal and Assignment of Errors.—Emerson R. Newell, Sol. & Counsel for Defts. —Filed May 13, 1913.—S. W. Petrie, Clerk.

UNITED STATES DISTRICT COURT,

WESTERN DISTRICT OF NEW YORK.

THE WRIGHT COMPANY vs. THE HERRING-CURTISS COMPANY and GLENN H. CURTISS.	In Equity. #400.

STIPULATION AS TO RECORD ON APPEAL.

IT IS HEREBY STIPULATED by and between Counsel for the above-entitled parties, that the transcript on appeal from the decree of April 8th, 1913, shall consist of the following papers:

(1) Complainant's Printed Record, including Appendix, at Final Hearing;

(2) Defendants' Printed Record at Final Hearing;

(3) Decree dated April 8, 1913;

(4) Opinion by Judge Hazel just prior to said Decree;

(5) Supersedeas Order dated April 17, 1913;

(6) Undertaking (Bond) on Appeal;

(7) Supersedeas Order dated April 23, 1913;

(8) Petition for Appeal and Allowance;

(9) Assignment of Errors;

(10) Citation;

(11) Clerk's Certificate;

(12) A copy of this Stipulation.

IT IS FURTHER STIPULATED that the exhibits filed by each side at final hearing shall be sent forward by the Clerk to the United States Circuit Court of Appeals, with the Transcript.

Dated May 10, 1913.

H. A. TOULMIN,
Of Counsel for Complainant.

EMERSON R. NEWELL,
Solicitor & Counsel for Defendants.

(Endorsed)—United States District Court, Western District of New York.—The Wright Company *vs.* The Herring-Curtiss Company and Glenn H. Curtiss.—Stiplation as to Record on Appeal.—Filed May 13, 1913.—S. W. Petrie, Clerk.—Emerson R. Newell, Solicitor & Counsel for Defts., #2 Rector Street, New York, N. Y.

BY THE HONORABLE JOHN R. HAZEL, ONE OF THE JUDGES OF THE DISTRICT COURT OF THE UNITED STATES FOR THE WESTERN DISTRICT OF NEW YORK, IN THE SECOND CIRCUIT.

TO THE WRIGHT COMPANY, GREETING:

YOU ARE HEREBY CITED and admonished to be and appear before a United States Circuit Court of Appeals for the Second Circuit, to be holden at the Borough of Manhattan in the City of New York, in the District and Circuit above named, on the 20th day of May, 1913, pursuant to an appeal filed in the Clerk's Office of the District Court of the United States for the Western District of New York, wherein The Herring-Curtiss Company and Glenn H. Curtiss are Appellants, and you are Appellee, to show cause, if any there be, why the decree in said appeal mentioned should not be corrected and speedy justice should not be done in that behalf.

GIVEN UNDER MY HAND in the City of Buffalo, in the District and Circuit above named, this 23rd day of April, in the year of our Lord One Thousand Nine Hundred and Thirteen, and of the Independence of the United States the One Hundred and Thirty-seventh.

JOHN R. HAZEL,

[SEAL.] Judge of the District Court of the United States for the Western District of New York, in the Second Circuit.

UNITED STATES OF AMERICA,
Western District of New York, } ss.:

I, SIDNEY W. PETRIE, Clerk of the District Court of the United States of America for the Western District of New York, do hereby certify that the foregoing and annexed papers contain true copies of the decree dated April 8, 1913, entered in the office of the Clerk of the United States District Court for the Western District of New York on April 17, 1913, in the action in said Court entitled The Wright Company, Complainant, *vs.* The Herring-Curtiss Company and Glenn H. Curtiss, Defendants, the opinion of Judge Hazel just prior to said decree, the supersedeas order dated April 17, 1913, the undertaking (bond) on appeal, the supersedeas order dated April 23, 1913, the petition for appeal and allowance, the assignment of errors, and the stipulation dated May 10, 1913, signed by counsel for the respective parties agreeing as to the contents of the transcript of record on appeal from said decree dated April 8, 1913, to the United States

Circuit Court by Appeals, Second Circuit, as the same remain of record and on file in my office; also the copies of complainant's printed record, including appendix at final hearing, and of defendants' printed record at final hearing furnished me by counsel for the respective parties as being true copies of such printed records.

IN TESTIMONY WHEREOF, I have caused the seal of the said Court to be affixed at the City of Buffalo, in said District, this 17th day of May, A. D., 1913.

S. W. PETRIE,
Clerk.

[SEAL.]